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# PROCEEDINGS

# Lake States Forest Tree Improvement Conference

## AUGUST - 30-31, 1955



Miscellaneous Report No. 40
DECEMBER 1955

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE — FOREST SERVICE

## FOREWORD

I am firmly convinced that the Lake States Forest Tree Improvement Committee, and similar groups in other regions, can play an important role in encouraging and coordinating research and other activities in forest genetics. As this new field of work continues to expand, which it assuredly will, it will become of increasing importance to maintain close liaison among the agencies engaged in it. For this reason our Station is glad to participate in and to further the work of this Committee.

The Lake States Forest Experiment Station published the Proceedings of the Lake States Forest Genetics Conference in 1953. We are happy to follow up with the publication of this Proceedings of the Second Lake States Forest Tree Improvement Conference.

M. B. Dickerman, Director
Lake States Forest Experiment Station

## ACKNOWLEDGMENTS

Acknowledgments are due to those who contributed toward the success of the Second Lake States Forest Tree Improvement Conference and particularly to the committee charged with making the arrangements: The co-chairmen, R. G. Hitt and A. J. Riker of the University of Wisconsin, Bruno Berklund of the Nekoosa-Edwards Paper Company, and W. H. Brener of the Wisconsin Conservation Department. In Dr. Riker's absence, J. E. Kuntz of the University of Wisconsin acted for him and ably fulfilled his committee assignments.

Thanks are also due to the Nekoosa-Edwards Paper Company for making available their Nepco Boys' Camp at Wisconsin Rapids, Wisconsin, as a meeting place.

Finally, our special appreciation is extended to those who took part in the program, especially those who came from other regions to meet with us. The final success of the Conference rested in large measure on their cooperation in preparing and reading papers and in leading the discussions.

The Lake States
Forest Tree Improvement Committee

P. O. Rudolf, Chairman

Attendance at
The Second Lake States Forest Tree Improvement Conference

CONTENTS

# RECENT PROGRESS IN FOREST GENETICS WORK AT THE LAKE STATES FOREST EXPERIMENT STATION

M. B. Dickerman[1/]

A little over 2 years ago, at the first Lake States Forest Genetics Conference, we reported the forest tree improvement work done by the Lake States Station up to that time. Since then the Station has carried forward the studies established in the past and has broadened its activities to include new lines of tree improvement research.

## WORK SINCE 1953 AND FUTURE PLANS

The most significant development for the Station since the last conference was the establishment of a full-time forest genetics program on July 1, 1954. This was an outgrowth of the same expanding interest in forest tree improvement that led to the formation of our Forest Tree Improvement Committee and similar groups in other regions.

Our program basically has two main points of emphasis: (1) project work by Station staff members, and (2) cooperative work with other agencies. In both of these we recognize the need for tree improvement research on all important forest tree species within the region. At the outset, however, we plan to channel our major effort toward the development of improved spruces for the Lake States. Other species will be considered in the Station's plans for the future.

Progress has been made along several lines: (1) We now have two full-time technical men, a silviculturist and a geneticist, engaged in forest tree improvement research. Paul Rudolf has been assigned to genetics work full time and has been relieved of other Station responsibilities. Dr. Nienstaedt, our geneticist, will be working with Mr. Rudolf. (2) After a thorough survey of the region we have selected a site for a forest genetics field center adjacent to the Hugo Sauer Nursery near Rhinelander, Wisconsin, and at this time have under way the construction of a greenhouse, laboratory, and office facilities there. (3) We have begun studies on vegetative propagation of white spruce. (4) We are assembling seed for a comprehensive study of variation within white spruce and black spruce. (5) We have equipped a forest genetics - soils laboratory at St. Paul. (6) We have entered into one cooperative-aid project with the University of Wisconsin and have other aid projects under consideration. (7) We are cooperating with the Institute of Paper Chemistry in the disease phases of their aspen genetics work. (8) Current work on studies previously under way consists chiefly of re-examining seed source studies and tests of hybrids.

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1/ Director, Lake States Forest Experiment Station; maintained by the Forest Service, U. S. Department of Agriculture, at St. Paul 1, Minnesota, in cooperation with the University of Minnesota.

## Seed Source Studies

Work has been pushed in red pine, jack pine, and the spruces.

### Red pine

New, and as yet unpublished, information has been obtained on the growth and development of 50 and 150 sources of red pine, respectively 14 and 17 years after planting. Reports on the results will be prepared.

Nursery-bed observations on more than 160 lots of second-year red pine seedlings indicated a general relationship between time of flushing and length of growing season of the place of origin.

### Jack pine

In the spring of 1954 about 75,000 2-0 jack pine trees of more than 30 seed sources were lifted, counted, packed, and distributed to 11 planting sites in Wisconsin and Michigan by the Station with the cooperation of the Wisconsin Conservation Department. At the same time the University of Minnesota similarly handled about 53,000 trees which were distributed to 8 planting sites in Minnesota and western Wisconsin. In cooperation with the Station and the University of Minnesota, the University of Michigan, Michigan Conservation Department, Minnesota Conservation Department, Nekoosa-Edwards Paper Co., Mosinee Pulp and Paper Co., 4 national forests, and 2 Wisconsin Counties, Burnett and Marinette, set out 128,000 trees in 17 plantations (2 plantations were supplied stock from both the Minnesota and Wisconsin nurseries), each containing 4 replications of the 30 seed sources.

First-year survival averaged about 90 percent, so some 13,000 2-0 seedlings of the same origins were set out in the spring of 1955 to replant fail spots. The same cooperators participated in the examination and replanting of these plantations.

### Spruces

A recently completed report describes the survival, growth, and development near Eagle River, Wisconsin, of 7 sources of white spruce, 6 sources of Norway spruce, 2 sources of red spruce, and 1 source each of the following spruces: black, oriental, Sakhalin, Serbian, and Siberian. Two sources of white spruce and three sources of Norway spruce appear best 16 years after planting. Black and Siberian spruces have done reasonably well. The spruces originating in a climatic zone notably milder than that of the planting site have done poorly.

## Tests of Hybrids

Small lots of jack pine - lodgepole pine hybrids and eastern white pine - western white pine hybrids and their parent species have been field-planted on experimental areas in northern Minnesota, northern Wisconsin, and the Lower Peninsula of Michigan. The stock was grown by the Station in the Hugo Sauer State Nursery in Wisconsin from seed supplied by the Institute of Forest Genetics in California. So far, the native Lake States species are distinctly superior to the hybrids or the western parent species.

In a small planting of hybrid aspens supplied by the Cabot Foundation one cross between quaking aspen and European aspen at 4 years of age has grown and survived better in northeastern Wisconsin than the local native aspen or a cross between eastern and western forms of quaking aspen.

## Cooperative Collections

For a number of years the Station has cooperated with persons and agencies in the United States and in foreign countries by supplying them seeds, pollen, and other plant materials for tree improvement purposes. We expect to continue such activities as a part of our tree improvement program and to receive similar material in return.

# THE LAKE STATES FOREST TREE IMPROVEMENT COMMITTEE

Our Station has been glad to contribute to the work of the Forest Tree Improvement Committee by making available part time of one staff member to serve as chairman, by giving him necessary clerical help, and by publishing the proceedings of the first conference. The work of this committee in stimulating and coordinating forest tree improvement activities in the region is of high importance, and we will continue to do what we can to further the committee's work. We feel there is a need for greater emphasis on coordination in new programs between the various research groups in the field of genetics and believe the Lake States Tree Improvement Committee can be an effective tool in this respect.

# CONCLUSION

In the few minutes allotted I have been able to give you only a very sketchy outline of the recent work and plans for future work at our Station. I hope that it has conveyed to you the general scope of our current activities.

# PROGRESS REPORT ON FOREST TREE IMPROVEMENT STUDIES AT THE UNIVERSITY OF MINNESOTA

Scott S. Pauley[1/]

In view of the fact that I have become an official and functional member of the School of Forestry staff at the University of Minnesota only very recently, you might well question my qualifications for reporting on the University's forest tree improvement activities during the past 2 years. Fortunately, I have found the records up to date, and a group of colleagues who have been happy and willing to provide me expert briefing.

## JACK PINE SEED SOURCE STUDIES

The jack pine seed source study initiated by Dr. Schantz-Hansen at the Cloquet Experimental Forest during the period 1939-43 was summarized at the first Lake States Forest Tree Improvement Conference (4).[2/] (For further reference to this work see also Schantz-Hansen and Jensen (5, 6, 7).) The primary objective of this study is to assess the degree of genetic diversity that exists within the species throughout its natural range. Although apparent intersource differences in survival, growth rate, and crown form have been recorded during the first 12 years, final assessments of the degree and persistence of such diversity cannot be made for several years.

In cooperation with the Lake States Forest Experiment Station, the Minnesota Conservation Department, the Wisconsin Conservation Department, and other interested agencies, a new study of jack pine seed source was initiated in 1954. Whereas the original tests were designed to study variation of jack pine throughout its natural range, the new study has been restricted to an assessment of variation on the regional level. The more than 30 seed sources concerned in this study are all of Lake States' origin and are under test in 17 plantations scattered throughout Minnesota, Wisconsin, and Michigan.

A proposed logical extension of the jack pine seed source investigations might well involve a further refinement in the sampling and testing method such that variation on the local stand and individual tree level may be determined. In association with such work, the feasibility of establishing seed orchards should be investigated.

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1/ Associate Professor, School of Forestry, University of Minnesota, St. Paul, Minnesota.

2/ Underlined numbers in parentheses refer to the list of numbered references at the end of this paper.

## POPLAR, ELM, AND BLUE SPRUCE SELECTION AND TESTING

A progress report on studies concerned with the selection and testing of poplar, elm, and blue spruce during the period 1947-53 was presented by Dr. Duncan at the first Lake States Forest Tree Improvement Conference (1). The primary objective of this work is to isolate hardy, disease-resistant, and vigorous materials adapted for windbreak or ornamental planting and, in the case of poplar, veneer, sawlog, and pulp production as well. (See also Duncan and Kaufert (2).)

The poplar tests, involving some 120 clonal lines of cottonwood and balsam poplar selected wildings, and species hybrids within and between these sections, have been carried on in cooperation with the Mayo Institute of Experimental Medicine at Rochester, Minnesota, on a good bottomland site. Other test plantings at the University of Minnesota's Rosemount Agricultural Experiment Station, a few miles south of St. Paul, are on less favorable sites. Based primarily on canker resistance and growth vigor over the initial 6-year period of the tests at Rochester, 10 clonal lines have been selected as promising for use in southeastern Minnesota (3).

The elm studies, concerned essentially with the isolation of disease-resistant and otherwise suitable forms adapted for shelterbelt and ornamental planting in Minnesota, are continuing. Of special interest is a 4-year-old planting of a Siberian elm (*Ulmus pumila*) progeny grown from the open pollinated seed of a street tree growing in the City of Minneapolis. The plants show wide variation in leaf and branching characteristics and crown form. Since a number of the plants appear to be intermediate between Siberian and American elm, they are presumed to be $F_1$ hybrids. Such an interesting situation suggests that similar trials of seed collected from ornamentals in other genera growing in close association with related species may prove a fruitful field for investigation.

Studies of variation in Colorado blue spruce continue in cooperation with the Hormel Institute at Austin, Minnesota. Special interest is directed to the identification of races or individuals better adapted to Minnesota's prairie sites, where the plant is in much demand for ornamental and windbreak plantings. Although this species, among all the conifers, shows the best survival on heavy soils, the sources now grown are not fully hardy and suffer from attack by *Cytospora* canker.

## GRADUATE TRAINING AND RESEARCH IN FOREST GENETICS

One of the tree improvement projects that has received primary attention at the University of Minnesota's School of Forestry during the past 2 years has only recently emerged from the formative stage. Through the efforts of Dr. F. H. Kaufert the development of a graduate training program in forest genetics has recently been completed. Although a "progress" report is somewhat premature at this early date, I can at least assure you that we are now open for business.

## CHARLES K. BLANDIN FOUNDATION GRANT

In association with the graduate training program, research in forest genetics and tree improvement fields will be materially expanded. Under terms of a grant by the Charles K. Blandin Foundation, major field research activities in forest genetics will be centered at Grand Rapids, Minnesota, in cooperation with the University's North Central School and Experiment Station.

## CABOT FOUNDATION COOPERATION

Through a cooperative arrangement with the Cabot Foundation of Harvard University, studies on mode of inheritance and ecotypic variation in cottonwood, balsam poplar, aspen, red oak, white pine, and red pine will be continued at the University of Minnesota. A major portion of the *Populus* materials involved in these studies was propagated and lined out in nursery beds at the North Central School and Experiment Station this past spring.

With the expanding tree improvement research efforts of the Lake States Forest Experiment Station, and the increasing interest of Minnesota's forest industries, the outlook for forest genetics and tree improvement research in Minnesota at this time is in all respects most promising.

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## TREE IMPROVEMENT WORK IN PROGRESS AT THE QUETICO-SUPERIOR WILDERNESS RESEARCH CENTER[1/]

Clifford E. Ahlgren[2/]

The Quetico-Superior Wilderness Research Center is a private enterprise located in northeastern Minnesota on Basswood Lake in the Superior National Forest. It is engaged in biological research primarily related to the surrounding forest. Some of the work under way has to do with tree improvement. Because of the facilities available and the interests of the personnel, our main emphasis has been on working out field techniques so that the results of the geneticist can be put directly to practical use in our area.

The first phase of work deals with the grafting in the field of blister rust-resistant selections of eastern white pine onto understocks of the same species ranging in age from 8 to 20 years and in height from 4 to 20 feet. These selections have been developed by Dr. A. J. Riker of the University of Wisconsin, who first stimulated our interest in tree improvement work. Over a 3-year period we have obtained a total of some 800 white pine grafts with a survival of better than 70 percent.

Terminal grafts survived and developed better than lateral grafts. Early spring grafting has been most successful, although fall grafting has shown promise. We have found that the side slit method of grafting is most satisfactory. In applying this technique we have found it necessary to match the cambial tissue on one side only. In other words, the scion does not have to be the same diameter as the understock.

Contrary to common practice, we have found it advantageous to leave an 8- to 10-inch length of terminal stub on the stock above the graft union. This should be left intact for the first 2 years. One or two lateral buds are left on the stub to maintain its life during this period. Shoot growth is pruned back periodically. In this way, successful graft unions will have completely callused and made two rings of wood circling the stub, thereby reducing the incidence of rot. The scion can also be tied to this stub, thereby reducing snow damage. Eventually the stub can be pruned flush with the graft union.

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1/ This paper was illustrated by 17 kodachrome slides.

2/ Resident Director, Quetico-Superior Wilderness Research Center, Ely, Minnesota.

Many of our third-year grafts, and some of the first- and second-year grafts have developed pistillate flowers which we have pollinated using pollen from Riker's selections in the Duluth area. Growth and development of the control-pollinated cones has been the same as that of wind-pollinated cones on the scions and on mature, 180-year-old pines in the same area. From our results we feel that this type of field propagation can be applied satisfactorily.

Another phase of work, in cooperation with a state agency, deals with the grafting of Norway (red) pine. The aim here is to work out a means of top grafting young red pine up to 20 feet in height with scion wood from older age classes. It is hoped that this work will help in the establishment of seed orchards in which seed can be produced from desirable stock. We have 400 grafts of this type. Again, the terminal graft is the most successful. Survival here runs better than 50 percent. We found that the hard pine tissue requires a firmer binding than the white pine, so plastic raffia is now used.

Still another phase of the grafting work deals with the interspecific and intergeneric grafts. The aim of this work is to find out which species are compatible in order that exotic species can be propagated vegetatively in the field on native understocks. We have made interspecific grafts of *Pinus peuce*, *P. cembra*, and *P. koraiensis* on understocks of eastern white pine and Norway pine. We have also grafted white pine on Norway pine and the reverse, as well as black spruce on white spruce and noble fir on balsam fir. Our intergeneric trial has been *P. koraiensis* on balsam fir. Survival of these intergeneric and interspecific grafts varies from 10 to 98 percent, the lowest being the grafts between white and Norway pine done in the fall.

Another phase of work involves the inversion of trunk tissues. As you know, Sax and others have successfully inverted the phloem tissues in fruit trees, thereby inducing flowering of very young trees. With this in mind, we inverted phloem on small white and Norway pines. Results for the first season showed a stimulation in growth of the white pine and a reduction in growth of the Norway pine. These results are, of course, very preliminary.

These, then, are the attempts we are making to develop techniques for bridging the gap between the work of the geneticist and the forest in our particular region. In the future we intend to extend our grafting work and, as the grafts flower, to expand our hybridization work.

# TREE IMPROVEMENT RESEARCH AT THE UNIVERSITY OF WISCONSIN

R. G. Hitt[1/]

The University of Wisconsin, in cooperation with the Wisconsin Conservation Department, began a program of forest tree improvement in 1948. Prior to this time work had been started in the Pathology Department by Dr. A. J. Riker and his associates on the selection and testing of blister rust-resistant white pines. This program has been expanded and promising resistant material is under field test at the present time.

The work which was started in 1948 in the Genetics Department was initially concerned with red pine. More recently work has been undertaken with jack pine and spruces. Individual tree selections have been made and progeny and provenance trials have been started. Vegetative propagation studies have also been initiated. Flower induction studies have been conducted for a number of years. Controlled pollinations have also been carried out. Research is being conducted at the University of Wisconsin with various Populus species. Problems concerned with disease and insect resistance, seed and pollen storage, vegetative propagation, etc., are being investigated. Controlled pollinations are being made and the growth of the Populus hybrids under Wisconsin conditions is being studied.

The oak wilt disease which is causing severe damage to oak species in the eastern and central United States is being studied here. Oaks which have escaped the tree-to-tree spread of the disease in large oak wilt pockets are being tested for possible disease resistance by means of artificial inoculation.

The field trip scheduled for this afternoon will show at first hand some of this material. I believe that a more detailed discussion of the various phases of the research will be more profitable at that time.

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2/In consecutive order, the field trip included the following: (1) a demonstration of the Swedish tree-climbing ladder; (2) a view of the facilities of the Griffith State Nursery; (3) greenhouse facilities; (4) Populus seedlings treated with colchicine to induce polyploidy; (5) potted trees to be used as understocks for 1955-56 greenhouse grafting; (6) some of the 1300 grafts made during the 1954-55 greenhouse grafting season; (7) miscellaneous breeding material to be outplanted; (8) several lots of hybrid pines received from the Institute of Forest Genetics; (9) seedbeds of material to be field tested or placed in breeding collections; (10) the University of Wisconsin Forest Pathology Summer

1/ Forester-in-Charge, Forest Genetics Research, University of Wisconsin, Madison, Wisconsin.

2/ Editor's note.

Research Center and the similar Forest Entomology Summer Research Center from which research teams carry out investigations throughout the state during the spring, summer, and fall; (11) 5-year-old greenhouse grafts planted at a 12x12-foot spacing; (12) Pinus monticola - P. strobus hybrids and the two parent species planted together; (13) a field planting of cuttings and seedlings of white pine very comparable in development; (14) 1 of the 4 breeding collection areas being developed throughout the state; (15) 1954 controlled crosses bagged to prevent further losses to squirrels and cone pickers; (16) seedlings resulting from controlled pollinations on blister rust-resistant white pine selections; (17) April 1954 pine field grafts with better than 70-percent take; (18) beds of white pine cuttings treated with various chemicals to induce rooting; (19) grafts and open-pollinated seedlings from apparently blister rust-resistant white pines which, after artificial inoculation with blister rust, have shown various degrees of resistance; (20) more than 1,000 air layers applied to various age classes of red, jack, and Scotch pines early in June, 1955; (21) several age classes of red pine given six different treatments, some of which have induced heavy male flower production but only a small increase in female flower production; (22) field grafts of red pine made in the spring of 1955 with about 45 percent success; (23) trials to find satisfactory methods of keeping the producing crown low so that seed can be harvested easily from the ground or from small ladders; and (24) progeny and provenance tests established in 1953, 1954, and 1955 with open-pollinated material of red pine, jack pine, Virginia pine, lodgepole pine, and Scotch pine.

## REPORT ON FOREST TREE IMPROVEMENT WORK AT THE UNIVERSITY OF MICHIGAN

Stephen H. Spurr[1/]

The forest genetics program at the University of Michigan is concerned primarily with the training of graduate students and incorporates research activities carried on by graduate students and by members of the staff. During the last year the opportunities for specialization in the Department of Forestry have been promulgated for ten fields of graduate study, one of which is forest tree physiology and forest genetics.

Men qualified both in forestry and in fundamental botany are in demand for investigative work and for teaching. In particular, there are continuing openings for men trained in applied physiology and applied genetics. Students interested in these fields should look forward toward obtaining the doctorate with considerable work in botany, although there are openings at present on the master's level. A well-rounded forestry training is the best undergraduate preparation for these careers.

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1/ Professor of Silviculture, School of Natural Resources, University of Michigan, Ann Arbor, Michigan. In Professor Spurr's absence the report was presented by Professor Samuel B. Graham, also of the University of Michigan.

Desirable natural resources electives include the courses in forest soils, water resource management, ecology of the forest, silviculture of American forests, and research methods.

Desirable electives in other fields include the following courses in botany, chemistry, mathematics, and zoology: genetics, systematic botany, plant physiology, anatomy of the vascular plants, cytology, organic chemistry, statistical analysis, and quantitative methods in biology.

Work on the bibliography of forest genetics, being prepared for the Lake States Forest Tree Improvement Committee, is continuing and the project is due for completion during the 1955-56 academic year.

Research projects on provenance trials and a limited amount of tree breeding for research purposes have been carried on. These projects were described in greater detail in the proceedings of the first Lake States Forest Genetics Conference in 1953.

## PROGRESS REPORT FOR MICHIGAN STATE UNIVERSITY

P. W. Robbins[1/]

During the past year Michigan State has revised the regulations covering the purchase and collection of forest tree seeds used in the production of forest planting stock at its Clarke-McNary tree nurseries. This measure will improve the quality and adaptability of the tree planting stock offered to Michigan tree growers.

The Dunbar Forest Experiment Station has completed the construction of a new conifer seed extraction plant. In the future, insofar as possible, all of the conifer tree seed for Michigan State's nurseries will be processed at the Dunbar Station plant.

The maple syrup investigations at Michigan State's East Lansing sugar bush continued for the third year the testing of the sugar content of maple sap (or sweet water) from 120 maple trees to select those maples which consistently produce high yields of sugar.

In 1955 a new 3-year project in cooperation with the U. S. Department of Agriculture's Agricultural Research Service, Philadelphia branch, was started at Michigan State University. This project, "Improvement of the Quality of Maple Sirup by Eliminating the Contamination of the Sap with

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1/ Associate Professor, Department of Forestry, Division of Conservation, Michigan State University, East Lansing, Michigan. In Professor Robbins' absence the paper was read by F. J. Hodge of the Michigan Conservation Department.

Microorganisms and Their Metabolic (Fermentation) Products in the Tap Hole and During Storage," will endeavor to determine, among other things, if individual maple trees have a natural resistance to the development of microorganisms in and around the tap hole area. If individual trees which consistently produce high yields of sugar, 4 percent or better, are also found to resist contamination by microorganisms, such trees will be used in tree improvement projects to produce sugar maple planting stock.

Michigan State continued, during the past year, to establish test plantations of new available tree hybrids at the Fred Russ Forest near Cassopolis, the W. K. Kellogg Forest near Augusta, the Dunbar Forest Experiment Station near Sault Ste. Marie, and the River Forest on the East Lansing campus.

The Forestry Department aided the members of a committee endeavoring to formulate a "Michigan Forest Tree Seed Law" which, it is hoped, will be introduced in the State Legislature and become a law of Michigan.

## PROGRESS REPORT, THE INSTITUTE OF PAPER CHEMISTRY

Philip N. Joranson[1/]

At the first Lake States Forest Tree Improvement Conference a report was made upon the initial phases and the methods of a study to determine the possible utility of polyploid aspen as a source of pulpwood. The investigation was under the joint sponsorship of the Marathon Corporation and the Rhinelander Paper Company. Research facilities were provided at Beloit College.

In January 1954 the study was transferred to the Institute of Paper Chemistry. There, other paper firms who are members of the Institute joined in the support, and progress on the project was accelerated.

At the same time a new department of genetics was established at the Institute to engage in fundamental research in the genetics and improvement of forest species which furnish pulp to the paper mills of the United States. For several years previously, the Institute had been laying plans for the creation of such a department.

Since the nature and purposes of the Institute may not be generally familiar, a brief description may be in order. The Institute comprises a graduate school, a research organization, and a library in behalf of the paper industry of the United States. Approximately 55 students are enrolled in a 4-year program leading to the Ph. D. degree. The curriculum gives much attention to the fundamental sciences which underlie the pulp and paper industry, and is especially designed to encourage the

1/ Research Associate, Institute of Paper Chemistry, Appleton, Wisconsin.

development of resourcefulness and judgment. Both fundamental and applied research is carried on, with about 120 projects currently in progress. Extensive abstracting and bibliographical services are provided, and the library is the most complete of its type. Approximately 40 persons carry primary responsibility in teaching and research, and the total staff numbers about 260. Support comes from membership participation on the part of approximately 125 companies, these accounting for about three-fourths of the tonnage produced by the pulp, paper, and paperboard industry of the United States.

The genetics department is housed in a new building with greenhouse attached, which was completed early in 1955. A nursery was established this spring on a temporary site 30 miles north of Appleton, and a permanent site closer to the Institute is to be purchased as soon as a suitable location can be found. The principal field location--including nursery, forest, propagation area, and test sites--has been provided by the Rhinelander Paper Company on its Forestry Farm near Eagle River, Wisconsin. Here some 20 acres of highly uniform soil have been set aside for future experimental plantings.

In addition to the geneticist, the staff of the department now includes Dr. Dean W. Einspahr, specialist in forest soils and silviculture, Dr. Peter A. Hyypio, cytologist, and several assistants. The department has also entered into a consultant relationship with a forest pathologist and a forest entomologist who are specially qualified to guide current studies in relation to tree diseases and insect pests. There is close cooperation with other research groups of the Institute in both teaching and research. An optional course in genetics will be taught for the first time this fall.

In the polyploid aspen project considerable advance has been made. Polyploid trees from several sources are now in hand; efforts are continuing to secure others; and some tree material will soon be ready for early testing. Polyploid trees grown for testing will be evaluated in the juvenile stage and at maturity.

Since the membership of the Institute is national rather than regional, the program in genetics will include studies of species in various sections of the country. The primary interest of the Institute is in the gene behaviors as they affect the expression of those tree, fiber, and chemical characteristics in which the industry has particular interest. In the characteristics which influence the suitability of wood as a raw material for making paper, there is a considerable array of variables which exert an important effect at some stage of manufacture or in the finished product. It will be important to learn to what extent these variables may be subjected to genetic control, and to improvement by the breeder. It seems quite apparent that the usefulness of tree improvement programs will depend heavily upon the availability of this kind of information, since at present we are very poorly informed in this area.

Parallel with and supplementary to this kind of activity will be a major emphasis upon intelligence in the nuclear cytology of forest trees. As is true generally in breeding programs, much advantage--both direct and indirect--often comes from familiarity with the behavior of the chromosomes of the breeding materials.

In the prosecution of the genetics program full advantage is taken of the fortunate opportunity which is available at the Institute of working in partnership with specialists in most of the areas in which genetic improvement is desirable. These areas include the specialized aspects of the basic sciences of chemistry, physics, biology, and also the various technologies. In its largest context and in its most effective relation, it seems quite evident that genetic improvement ought to be regarded as a co-enterprise with technological modification and with silvicultural modification, and the more intimate the relations between the researchers in these three areas and their allies, the more productive the enterprise.

While the first genetics project at the Institute has majored upon polyploidy as a method to be tested with reference to improvement in amenable tree material toward several specific objectives, there is no thought of imposing a bias in favor of this particular method of improvement except as similar studies may be justified by the tree material used in projects initiated in the future.

In addition to the aspen polyploidy study, several other studies of aspen have been undertaken. These include:

1. In cooperation with Dr. Scott S. Pauley, a study of the inheritance of certain characteristics of aspen, with four related generations as experimental material.

2. An investigation of natural variability in Lake States aspen wood.

3. Research to improve methods of raising aspen from seed.

4. A study of methods for killing insect larvae which feed upon aspen seeds and pollen.

5. Preparation of an extensive annotated bibliography of the genetics and improvement of pulpwood species, which is now at the half-way stage.

## PROGRESS REPORT, NEKOOSA-EDWARDS PAPER COMPANY

B. L. Berklund[1/]

If brevity engenders approval, I may turn out to be the most popular person attending this conference.

In the spring of 1954, Nekoosa-Edwards planted stock from their jack pine seed source study. At the same time the Company cooperated with the Lake States Forest Experiment Station in establishing one of the regional jack pine seed source plantations on Company land in central Wisconsin.

Red pine, white spruce, and black spruce stock of several seed sources are scheduled for planting in the spring of 1956.

We have lodgepole-jack pine hybrids under observation in the field from 1951, 1952, and 1953 plantations.

Further details are given in the 1953 Proceedings of the Lake States Forest Genetics Conference.

## EXPERIMENTAL TREE GROWTH STUDIES OF THE MARATHON CORPORATION

Martin Baum[2/]

The Marathon Corporation is a producer of pulp, paper products, and lignin chemicals. The company originated in 1909 with the construction of a sulfite pulp mill at Rothschild, Wisconsin. Its overall operation now extends nationwide and into Canada.

One of the most significant features of Marathon is integration which begins with extensive woodlands operations. The company obtains its pulpwood from 5,000 square miles of timberland in Canada and from northern United States.

Timber from these holdings is made into pulp in company mills located at Green Bay, Wisconsin; Rothschild, Wisconsin; and Marathon, Ontario. Ten mills, five of which are located in Wisconsin, convert pulp into paper and finished products.
Research is conducted at Rothschild by the Central Research Department, whose members form part of Marathon's staff of engineers, scientists, and technicians. This department is housed in a modern, streamlined building having excellent pilot plant and laboratory facilities.

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1/ Forester, Woodlands Department, Nekoosa-Edwards Paper Company, Port Edwards, Wisconsin.

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Wood is our most important raw material and represents a major portion of our pulp manufacturing costs. Experimental studies to discover ways of growing more wood per year on tree farms will be of value not only to the producer but to the potential user as well.

Marathon Corporation started tree growing studies in 1949 using a site in our mill yard at Rothschild. This space was augmented by the purchase of an 80-acre farm in 1953. This farm is located about 6 miles from Rothschild and is thus readily accessible to the Central Research laboratories.

A survey of soils and ground water was made by Dr. S. A. Wilde, Professor of Soils, University of Wisconsin, in 1953. This survey showed a diversity of soils varying from sands to wet loams. The water table varies in depth from 1 to 7 feet. This variation permits a wide freedom in choice of species as adapted to different soil and water conditions.

The farm is occupied on a year-round basis by a tenant who not only acts as a caretaker but also supervises the planting, provides the care, and makes measurements and observations on the tests in progress.

Our object in tree growth studies is to assist in the development of trees which will produce the largest possible amount of suitable fibre per acre per year. To achieve this objective, a program has been set up to test (1) hybrids, (2) trees from selected parentage, and (3) conifer and the broadleaf trees common and native to this area.

Both willow and poplar hybrids, developed as fast-growing and resistant trees, are being tested to determine adaptability to this climate, vigor, survival, and growth rate. It is too early in the program for definite conclusions.

We are testing the Danish willow hybrids, developed by Carl Jensen. They are reported to produce pulpwood-sized trees of about 6 inches in diameter in 3 years under optimum conditions in Denmark. Our data have not been sufficient to establish growth rates; however, we note that all but 1 of the 5 clones being tested are subject to serious damage from grasshoppers. Except for the 1 clone, therefore, these hybrids appear unsuited to the Lake States area

We are testing a fast-growing hybrid poplar produced by R. McKee. This hybrid developed a serious Cytospora canker during the fourth growing season. Over 25 percent of the trees were affected; a major number of these recovered during the sixth and seventh growing seasons. Tests are in progress to determine whether cuttings from a recovered tree are immune to Cytospora canker.

Our studies on selected parentage and seed source are limited to testing the progeny of outstanding individuals from our native trees as screened, selected, and propagated by our university specialists. These studies include aspen from Duncan of the University of Minnesota, aspen from

Riker and Shea of the University of Wisconsin, and a jack pine seed source study in cooperation with the Lake States Forest Experiment Station.

These studies, together with those that we are conducting on trees native to this area, have not progressed sufficiently far to report findings at this time.

One function of Marathon Corporation's participation in tree improvement studies is to serve as a proving ground. We therefore invite those specialists engaged in tree improvement work to submit their new and improved selections for further testing.

## TREE IMPROVEMENT AT KIMBERLY-CLARK

P. B. Thomas[1/]

Kimberly-Clark has a good supply of timber of all species and ages on its own lands. Nevertheless, we have long been interested in tree improvement, particularly in pulpwood species, so that trees of better form and resistance to diseases and insects can be grown more rapidly upon our lands. This is a subject of which we are increasingly conscious as we become more involved in nurseries and planting. We are interested in finding trees better in growth and vigor than the woods-run spruces, balsam fir, pines, and aspens.

The magic appeal for some years past has been hybrid poplar because of its extreme rapidity of growth. The first efforts made by this company in tree improvement were test plantings of hybrid poplars obtained from several sources.

Between 1939 and 1943 cuttings of several varieties of poplar were set out near Lake Gogebic at the western end of Upper Michigan. Some cuttings were obtained from St. Williams, Ontario, and others from Chalk River, Ontario, through the courtesy of Dr. Heimburger. Unfortunately, many trees died early because of no special care, while those remaining have cankered and assumed a poor form. Only a few individuals still remain and these offer no hope of being as good as our native aspen.

In 1954 we secured cuttings of the three best clones planted by P. Vogelsang for the Dow Chemical Company at Midland, Michigan. Growth of the first summer was browsed by deer last winter. Exceptional heat has made it difficult for the trees to recover even last year's growth. We do hope to have cuttings of at least one of these three clones, as it survived the winter quite well.

So far we have made only disappointing trials in hybrid poplars. But we feel that there is a practical step we can take in improving our spruce planting stock.

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1/ Forester, Kimberly-Clark Corporation, Neenah, Wisconsin.

We are starting on a program of taking seed only from white spruce and black spruce trees selected as the best in form, rate of growth, and size in their respective stands. Our district foresters select individual spruce trees on cutting operations. At the proper time of year these trees are felled and the cone pickers are busy even as the bole of the tree is skidded out of the woods.

Although felling reserved seed trees is the method we now use for acquiring cones, we know we must have a better method. Investigations are being made of equipment so cones may be picked without damage to the seed tree. With this equipment we expect to make regular harvests of cones from spruce trees on existing roads or near enough so short spurs can give access. Trees for cone supply purposes have been selected in some of our districts. As quickly as equipment becomes available we will come to rely on this system for improving our forest tree seed and subsequently our planting stock.

We depend largely on the experience of our district foresters in judging whether an individual tree is fit for use as a seed source tree. The forester looks for rapid growth and good vigor in trees that have developed rapidly to as large as 15 inches in 60 years with a height of 54 to 60 feet on a good site. The crown may be from 1/3 to 1/2 of the height of the tree with relatively long needles, slender branches, and a long bole of little taper. Any sign of disease or insect attack will, of course, eliminate the tree from consideration.

Seed from our selected trees comes from a wide geographical range in the Lake States. Kimberly-Clark operates in Minnesota from Duluth north to the border, throughout northern Wisconsin, and across Michigan from Lake Gogebic to Drummond Island in the east. As we recognize that there may be geographic differences in any species through such a range, seed from each district is segregated in extraction and storage. Following seeding in our nurseries, the stock is earmarked for return to the district that provided the seed. This program has been followed in trial seedbeds at our new Lake Mary Nursery in Michigan and as much as possible at the Knife River Nursery in Minnesota. In an expanding planting program it has not always been possible to distribute stock to the district of seed source.

In summary, Kimberly-Clark's very limited activity in tree improvement has been in two directions: first, trials of several varieties of hybrid poplars starting in 1939 that have not shown any promise of being better than native aspens; and second, current efforts to select distinctively superior native spruce trees for seed source. Selection of these superior spruce trees is being followed by controlling individual seed lots so transplant stock can be returned to the district of seed source.

Our objective in tree improvement still is to find trees developed by cooperative scientific effort that are superior to the native strains with respect to rate of growth, wood quality, form, freedom from disease and insect attack, and ease of propagation. We will continue to cooperate

with others to the best of our ability in test plantings and in finding any of our native trees that may be suitable for tree breeding.

## REPORT PRESENTED BY THE CONSOLIDATED WATER POWER AND PAPER COMPANY

E. S. Hurd and J. W. Macon[1/]

Since the first meeting of this group 2 years ago, we of the Consolidated Water Power and Paper Company, Forestry Department, have not experienced nor generated any earth-shaking developments in the general field of tree improvement work. We should, however, like to make a few brief comments on several projects which fall within the fringe area of forest tree improvement work.

### NURSERY AND PLANTING OPERATIONS

Consolidated has operated a forest tree nursery for the past 20 years in three different localities. Our present nursery, located at Monico in north-central Wisconsin, is operated primarily for the production of white spruce and black spruce transplant stock for our reforestation program.

We feel rather fortunate in operating our own nursery because we can control production of the kind of planting stock required for our field planting jobs. Furthermore, our nursery is so operated that interest in the stock does not end when the trees are hauled away from the nursery, but continues for many years as they develop into a vigorous and healthy forest. We believe that much can be done at the nursery level to improve greatly our future planted forests.

Our annual production of transplant stock runs to about one-half million trees a year. Presently we are starting to produce some balsam fir and Scotch pine for sale to the Christmas tree trade.

Before 1944 we purchased our seed from any and all seed dealers. The futility of such practice became very evident in 1943 when one sowing of spruce seed proved to be a colossal flop--no germination. After this experience we decided to collect our own white spruce seed; and we certainly became aware that a low price per pound of seed doesn't always indicate a bargain. We made our first cone collection in 1944, another in 1950, and are again collecting cones this year, 1955. This 5- to 6-year interval between bumper cone crops for white spruce indicates the need for some foresight to follow through with an annual seeding program. To date we have been more than pleased with our seed grown and collected locally, that is, in the general areas in which the trees will be planted.

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1/ Forester in Charge and Research Forester, respectively, Timberland Division, Consolidated Water Power and Paper Company, Rhinelander, Wisconsin.

For seed collection work we select mature trees heavily loaded with cones and mark them for a harvest cut. Local pulpwood producers cut the trees, collect the cones, and follow up in the job of making pulpwood from the seed trees which have been cut. You see, we haven't as yet approached the ladder climbing stage to gather our cones, and we probably won't until a more practical method is perfected to gather cones from standing seed trees.

We cannot put our finger on definite facts which prove the superiority of locally collected seed to that of the general run of seedhouse seed. Observations, however, indicate that this was a good move in bettering the quality of our nursery stock, and we certainly plan to continue local collection of our required spruce seed.

Several years ago we established a series of white spruce test plots in our nursery in cooperation with the Soils Department of the University of Wisconsin. In general, the purpose of this study was to evaluate the effects and influences of chemicals, fertilizers, and humus on the growth and development of white spruce stock, both in the nursery and in the field. This study may not be followed through, however, because Mr. G. K. Voigt, who set up the study, now is affiliated with Yale University.

## SUPER SPRUCE

To be up to date and conform with prevailing trends in investigative work, we have "Operation Super Spruce" under way. Anyone who has worked around a white spruce nursery cannot help but be impressed by the differences in growth rate exhibited by individual seedlings and transplants. Our 2-2 stock generally runs from 6 to 10 inches tall, yet here and there along the rows will be an 18- or 24-inch specimen. In order to satisfy our own curiosity we have set up a study to determine if this vigor carries through into the later life of the trees.

In 1950 and 1951 we selected about 2,500 "super spruce" at our Cavour Nursery and planted them in the field along with some regular nursery-run planting stock. We have kept a careful watch on about 450 trees each of the super and regular stock. This study is not yet old enough to be conclusive, but results at the end of 6 years indicate that the selected stock compares with our regular stock as follows (table 1):

1. Survival.--There is no appreciable difference between the two classes of stock.

2. Establishment.--The super stock required a longer period to recover from transplanting into the field. During the first 2 years of the plantation's life, growth and vigor of the regular stock was superior to that of the super trees.

3. Growth.--In spite of this early setback, 6-year growth on the super trees is 30 percent greater than that on the regular trees.

4. Height.--Average total height of the super trees is now 43 inches against 29 inches for the regular stock.

5. Rabbit damage.--Because of their greater height, the super trees have suffered less from rabbit clipping than have the regular trees. About 45 percent of the super stock are now so tall that they are not likely to have their leaders clipped. Only 8 percent of the regular stock are this tall.

Table 1.--Comparison between super and regular white spruce planting stock 6 years after planting

| Item | Super spruce | Regular spruce |
|---|---|---|
| Survival....................................Percent... | 92 | 90 |
| Average height when planted......................Inches... | 13 | 6 |
| Average 6-year height........................Inches... | 43 | 29 |
| Average 1955 growth...........................Inches... | 9.8 | 7.2 |
| Trees taller than 5 feet......................Percent... | 10.3 | .5 |
| Trees shorter than 20 inches..................Percent... | 3.6 | 26.1 |
| Trees of good and excellent vigor.............Percent... | 80 | 59 |
| Best 20 percent of trees, average height........Inches... | 59 | 44 |
| Best 20 percent of trees, average 1955 growth....Inches... | 13.9 | 11.5 |
| Trees clipped by rabbits in 1954-55 season......Percent... | 8 | 15 |

## HARDWOOD IMPROVEMENT WORK

During the past several years the chances of making high-order commercial hardwood thinnings have increased tremendously in certain parts of Wisconsin. If your lands and operations are located in a satisfactory radius of a chemical plant or a mill using hardwood pulpwood, you can now do a type of stand improvement work that foresters have only dreamed about for many years. The increased utilization of our mixed hardwood forests will leave a definite impact on our woods, and what the future may offer is open to wide speculation. I believe our local hardwoods will be an ever-increasing commodity in many Lake States mill yards in the quite near future.

We of Consolidated have been giving some thought to the growth and utilization of our hardwood forests for purposes other than that of growing just hardwood sawlogs. In addition to our experimental forest we have established an area of 1,400 acres for the express purpose of carrying out intensive hardwood management practices. Stand improvement jobs have been carried out in these 40- to 50-year-old hardwood stands.

This summer we treated for chemical debarking about 2,500 cords of hardwood pulpwood in a combined area of some 500 acres. Here, we believe, is a forester's opportunity to do some real stand and tree improvement work.

It seems reasonable to suppose that through the continuation of such stand improvement practices we can and will develop a superior type of hardwood stand. However, this thought may well be considered: Are we, as forest scientists, silviculturists, and forest managers, in a position at present to guide the orderly development of this new source of fiber and cellulose crop?

## CHRISTMAS TREES AS A FOREST PRODUCT

I have a further consideration which I would like to present to this group--although it might be received with reservation--and that is the growing of Christmas trees as a quick cash crop of the forest. Consolidated has recognized in its forest management plans that Christmas trees are a bona fide forest product, and we have been harvesting trees from our lands for several years. Since we have been engaged in the sale and cutting of Christmas trees--mostly balsam fir to date--we have become increasingly aware of numerous factors which influence and determine the marketability of a balsam fir as a Christmas tree. Several of these points may be listed as follows:

1. The possibility of definite strains in balsam fir, some of which may be especially suitable for Christmas trees because of needle color, density of foliage, size and arrangement of branches, and compactness and symmetry of the tree. Trees lacking these desirable features for Christmas trees might well be considered as good pulpwood trees. The big question is how much growth characteristics of good Christmas trees are inherited. Can seed from such parent trees be considered a good source for Christmas tree stock?

2. Frequently these two types of balsam fir grow side by side in the forest, but then again it is quite common that the quality type balsam firs, suitable for Christmas trees, occur in small groups. This could indicate that one parent seed tree had spawned a number of potential balsam fir Christmas trees. Such relationships and occurrences should be field-checked for reliability.

3. Full sunlight is not, in my opinion, the complete answer to growing select type balsam fir Christmas trees. Site conditions and soil characteristics certainly are important. But what about the genetics of the problem: Are not some of the traits of Christmas trees versus pulpwood trees a matter of inheritance?

There seems to be common agreement that forest genetics studies definitely are a long-range proposition. It would, therefore, seem that the factors of genetics when applied to Christmas trees would be a good testing ground,

for in a period of 8 to 12 years you would begin to have definite proof of your progeny test.

With the increased interest and the present tempo of forest plantings being made expressly for Christmas trees, I wonder if some attention and effort might not be devoted to discovering some facts relating to the problem of color, density of foliage, branch size and arrangement, and tree form for the several species commonly used as Christmas trees here in the Lake States region.

## REPORT FOR THE NORTHEASTERN FOREST EXPERIMENT STATION TO THE SECOND LAKE STATES FOREST TREE IMPROVEMENT CONFERENCE

Ralph W. Marquis[1/]

My presentation to you today is not, strictly speaking, a report on recent progress--unless the word "recent" can be interpreted to mean within the last 20 years. Because we have not previously had a representative at this conference, and at the suggestion of your program committee, I am going to give you a rather generalized review of past and present work of the Northeastern Station as it relates to forest tree improvement.

Our program got started in 1935 when the Station took over from the Oxford Paper Company the experimental work on hybrid poplars. Though the poplar studies continued to be an important part of the tree improvement program, studies were started immediately on other important forest trees in the Northeast.

Exploratory studies were made for 14 of the most common and most important genera. Five of these were later selected for more intensive study, based on their commercial importance to the region and on the possibility of rapid progress. The white pine group and spruce were selected among the softwoods; maple, birch, and ash among the hardwoods.

As the program was expanded it developed along several lines: (1) hybridization and the mass production of hybrids, (2) racial tests, (3) individual tree selection, (4) the study of exotics, and (5) field testing.

### HYBRIDIZATION

Until 2 or 3 years ago major emphasis in our species-hybridization program was on the determination of species crossability patterns. The poplar crossability pattern was the easiest to determine. It was found some 30 years ago that nearly all the species crossed with each other. The pattern was also easy to determine in maple, which is subdivided by the

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1/ Director, Northeastern Forest Experiment Station, Upper Darby, Pennsylvania. Forest Service, U. S. Department of Agriculture.

taxonomists into 13 sections. Crosses between sections usually failed, whereas crosses within sections usually succeeded.

Since there are a good many agencies working on pine genetics, we confined ourselves to the 5-needled white pines and to the series Sylvestres in the hard pines (Scotch pine, red pine, Austrian pine, etc.) because these groups include our important northeastern pines. Of 63 different species combinations attempted, 25 yielded identifiable hybrids. Except for sugar pine, almost all the white pines of the series Strobi cross with each other; a few crosses can also be made between the series Strobi and the series Flexiles (for example, limber pine x Himalayan white pine). With the exception of red pine, nearly all the hard pines in the series Sylvestres can be crossed with one or more other species.

The crossability pattern in the spruces eluded us for some time. However, after trying 69 different species combinations (25 of them successful) we know more about the pattern. Most of the successes involved similar species with neighboring ranges, whereas most of the failures involved species with widely separated ranges.

Our oldest hybrids are the 30-year-old hybrid poplars in a seedling plantation in Maine. Many of the surviving hybrids are now 80 to 85 feet tall. We have made about 200 selections from these plantations and have established replicated clonal tests at several localities in the Northeast. These hybrids have also been sent to several organizations in the Lake States and Central States. By last year our tests in the Northeast had proceeded far enough to justify release for countrywide tests of 70 hybrid clones representing 23 different parent combinations (table 1). Two cuttings of each of four hybrids were sent to nearly 3,500 cooperators, mostly farmers and small landowners, throughout the country (fig. 1). These cooperators have agreed to provide information on survival and growth during the first 2 years. To make the most of the research possibilities from this distribution, each clone is being tested in as many regions as possible, and records of the identity of the clones sent to each cooperator have been kept.

Our oldest hybrids of other genera date from about 1940. Among them, two pine hybrids are outgrowing their parents. Others, such as paper birch x gray birch and red maple x silver maple, are intermediate in growth rate. Some of the newer pine hybrids show definite promise of hybrid vigor, mass production possibilities, and probable weevil resistance.

The next step with the most promising of these species hybrids is to investigate their mass production possibilities and to test different tree x tree combinations. (Sometimes a successful cross is repeated 40 or 50 times in different years and with different trees.) It appears that we could mass produce the fast-growing Pinus ayacahuite x strobus and Austrian x Japanese red pine hybrids cheaply by the simple procedure of interplanting clones of the two species in special seed orchards. The fast-growing Japanese black x Japanese red pine hybrids could probably

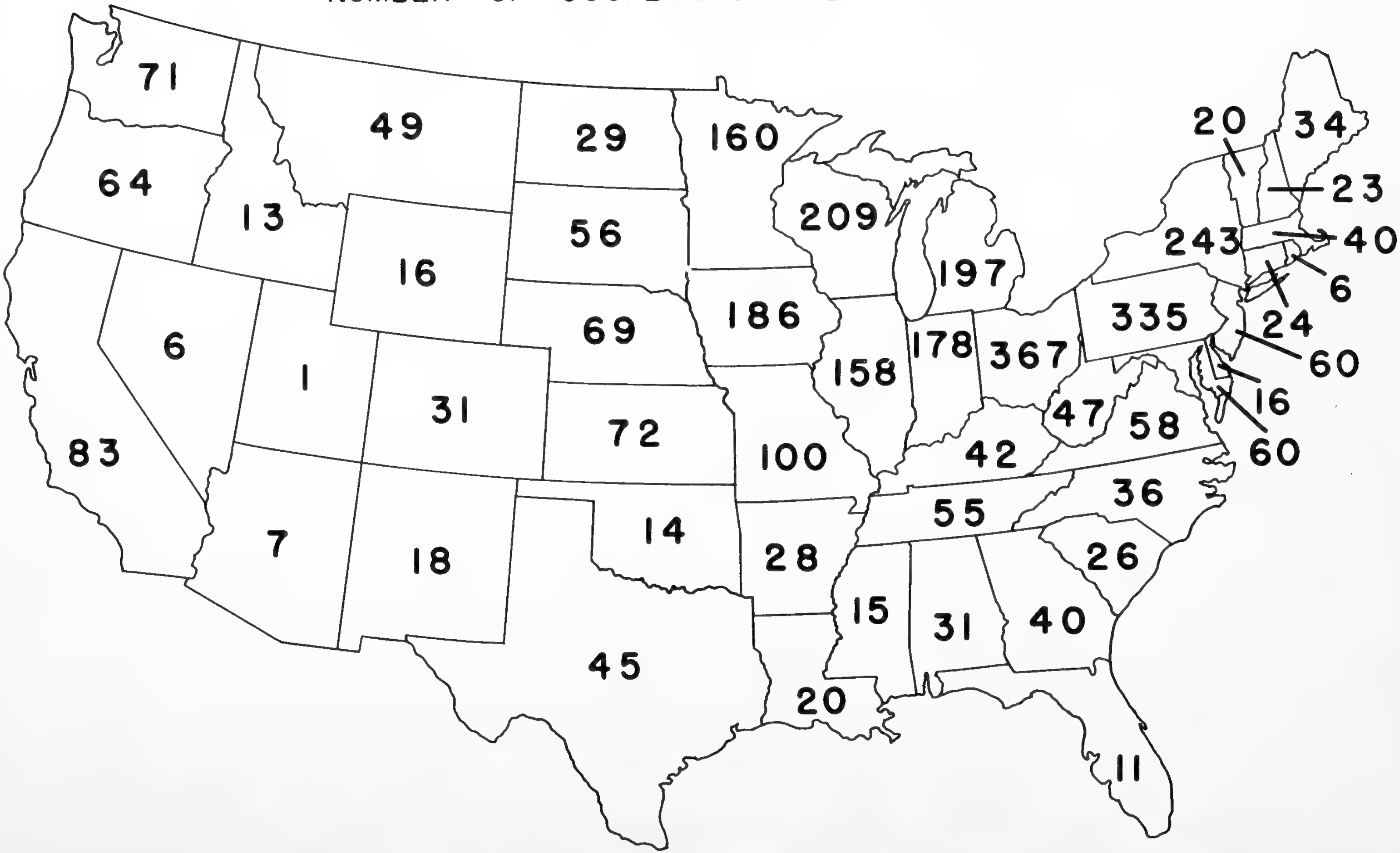
be mass produced cheaply by controlled pollination. On the other hand, we have not yet devised any scheme for the mass production of first generation maple hybrids; perhaps we can use the $F_2$'s.

Table 1.--Parentage of hybrids distributed by the Northeastern Forest Experiment Station for nationwide tests

| Hybrid | Number of clones |
|---|---|
| GROUP I | |
| P. maximowiczii | |
| X P. trichocarpa | 2 |
| X cv. 'berolinensis' | 2 |
| X cv. 'plantierensis' | 2 |
| X P. caudina | 1 |
| GROUP II | |
| P. deltoides | |
| X P. caudina | 12 |
| X cv. 'Volga' | 3 |
| X cv. 'plantierensis' | 3 |
| P. angulata | |
| X P. deltoides | 3 |
| GROUP III | |
| P. nigra | |
| X P. trichocarpa | 2 |
| P. deltoides | |
| X P. trichocarpa | 9 |
| P. angulata | |
| X P. trichocarpa | 7 |
| P. nigra betulifolia | |
| X P. trichocarpa | 3 |
| GROUP IV | |
| P. nigra | |
| X P. laurifolia | 3 |
| X cv. 'eugenei' | 1 |
| P. nigra charkowiensis | |
| X P. caudina | 6 |
| X cv. 'robusta' | 1 |
| X P. deltoides | 1 |
| P. sargentii | |
| X cv. 'berolinensis rossica' | 2 |
| X cv. 'italica' | 1 |
| X P. simonii | 1 |
| P. petrowskyana | |
| X P. caudina | 1 |
| P. tacamahaca cl. candicans | |
| X cv. 'berolinensis' | 3 |
| P. rasumowskyana | |
| X cv. 'plantierensis' | 1 |
| Total | 70 |

Figure 1.

## COOPERATIVE HYBRID POPLAR TESTS
NUMBER OF COOPERATORS BY STATES—1955



## RACIAL TESTS

The Northeastern Station has racial tests under way in red pine, white ash, and Norway spruce. We are starting a large test in eastern white pine in conjunction with the other eastern forest experiment stations and Canada. All the older tests have turned up important differences in growth rate and other characters associated with differences in origin. On the basis of early growth, the local races of native species did not always prove to be the best. For example, Maryland white ash planted in eastern Pennsylvania is growing much faster than native stock.

Scotch pine has a rather unsavory reputation in the Northeast because much of the early reforestation resulted in "typical" crooked growth. This summer, in cooperation with the State of New Hampshire, we measured a 15-year-old Scotch pine racial test (IUFRO)[2/] in southern New Hampshire and found that there are Scotch pines worth planting in the region. The trees of Latvian and Esthonian origin are fast growing and straight stemmed.

## INDIVIDUAL TREE SELECTION

Individual tree selection studies are under way in two species, sugar maple (high sugar content) and eastern white pine (weevil resistance), but in general we have gone slow on individual tree selection work. One reason for this is that we do not wish to obligate ourselves to the years of selection, controlled pollination, clonal testing, and progeny testing that are necessary for the development of an improved strain until we are reasonably sure that there is no quicker way of obtaining our objective. For example, in Scotch pine timber growers in our region want straight boles and Christmas tree growers want blue color, and they want them now. For the present, at least, we believe that it is better to test the straight growing Latvian races and the blue Spanish races (followed in both cases by selection and breeding) than to make selections in a plantation of unknown origin.

## EXOTICS

During the past few years we have been gathering growth information (from single specimens in arboreta or from small forestry plantings) on several hundred tree species that are not native in the Northeast. About 100 of these show definite promise for forestry and for future breeding work because of rapid growth, excellent form, or freedom from pests. During the next decade we hope to establish small forestry plantings of these promising species; we have already made a start on about 15 of them. There are very promising exotics in pine, spruce, fir, and some monotypic genera such as Ginkgo. The introduced species of spruce and fir frequently outgrow the natives. Norway and sycamore maples are among the most promising hardwood exotic species and are already reproducing naturally in areas where sugar maple does not grow. European sweet cherry is another

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2/ International Union of Forest Research Organizations.

tree that has gone wild and is producing straighter sawlogs than the native black cherry in the Philadelphia area. On the other hand, exotic species of ash, oak, and hemlock have shown very little promise.

## FIELD TESTS

Field testing for evaluation or genetic differences is the *sine qua non* of genetics research and must receive as much study as the actual selection and breeding. Perhaps we are making a fetish of careful design and planning, but the hybrid poplar clonal tests have clearly shown the desirability of keeping the plantation as uniform as possible by plowing and cultivation, the need for more replication than has generally been used in forest research, and the relative amounts of variation due to genetics and environment. For clear-cut genetic comparisons we favor experimental designs with many replications (up to 30) and with small plots containing only 1 to 4 trees. These small plot experiments sacrifice some information on stand performance and sometime pose a thinning problem. But such designs are more sensitive and more efficient because they provide more information for evaluation of genetic differences in relative growth rate, pest resistance, branch size, etc., at a lower cost which is within the limits of our genetics budget.

A project on which we are just getting started is known as the Michaux Quercetum. The Station and the Morris Arboretum are active participants, and financial assistance has come from a trust fund left with the American Philosophical Society. Some 80 species of American oaks and additional exotics hardy in this area will be planted in a series of arboreta. Acorns and herbarium specimens are now coming in. Nursery observations will be made to test the purity of the seed. The arboreta, which will contain only pure species, will help to end the confusion in names, and will eventually provide germ plasm for controlled hybridization.

# PROGRESS IN TREE IMPROVEMENT RESEARCH AT THE SOUTHEASTERN FOREST EXPERIMENT STATION

Keith W. Dorman[1]

The Southeastern Forest Experiment Station territory consists of Virginia, North and South Carolina, Georgia, and Florida. Three great soil physiographic regions make up the bulk of the area. These are the deep sands of the coastal plain with their slash, longleaf, and loblolly pine forests, the rolling red clay country of the Piedmont Plateau with loblolly and shortleaf pines, plus hardwoods, and finally the Southern Appalachian highland with hardwood forests and an admixture of shortleaf, Virginia, and white pines. About 60 percent of the Station's territory is forested.

1/ Forester, Southeastern Forest Experiment Station, Macon, Georgia. Forest Service, U. S. Department of Agriculture.

The elevation in the Southeastern states varies from sea level, where, in South Florida, mangrove grows with its roots in salt water, to over 6,000 feet in the Appalachians where Fraser fir, red spruce, and yellow birch and other hardwoods develop in a climate approaching that of areas long distances to the north. We have about 300 species and varieties of trees of which 12 are pine.

The South is a tremendous user of wood and planter of trees. Most land can be machine planted, so pine seedlings are planted in astronomical numbers each year--a cool 185 million in our Station territory last year. Nevertheless, the timber cut still exceeds growth in most areas, and the size of the average tree is decreasing.

Thus, the stage is set for a large and active program in tree improvement. We have the forest resource, ever-expanding industry anxious to grow and use more and better trees, land to be planted, huge tree nursery facilities, and a vigorous planting program.

Our tree improvement work is aimed at improving the genetic quality of seed now planted and at producing better strains for the future. We are concentrating largely on pines but are working with a few of the important hardwood species.

The Station has major tree improvement projects at its Lake City Research Center in Florida and the Athens-Macon Research Center in Georgia. It has several studies at each of the four other Research Centers. Our work is coordinated with that of the Southern Institute of Forest Genetics and numerous public and private agencies.

## THE LAKE CITY PROGRAM

The Lake City Research Center genetics program includes research in single tree selection and controlled breeding in studies of gum yield inheritance, racial strains of slash pine, superior tree selection in the nursery, and techniques for managing seed-production areas and seed orchards. The heritability of gum yield in longleaf pine has been demonstrated in 17-year-old, one-parent progeny in a study started by T. A. Liefeld in 1935. Another major step was verification of the inheritance of gum yield in 9-year-old trees from cross-pollinated and open-pollinated slash pines of high and average gum yield. A third plantation of several hundred seedlings from the same slash pine parents and later selections is not yet old enough for gum-yield determination.

Approximately a dozen trees were selected in 1942, and additional trees later, which were producing about twice as much as average trees on the same site. Control-bred offspring of these trees produced about 1.8 times as much as the average tree. Open-pollinated offspring produced less than the control bred. The viscosity of the gum was found to be strongly controlled genetically, but, in young saplings, the size and number of resin ducts in the wood were not. When the trees mature, characteristics of the resin ducts may follow a definite pattern.

The Lake City Center is one of the cooperators in the southwide pine seed source study directed by P. C. Wakeley of the Southern Forest Experiment Station for the Committee on Southern Forest Tree Improvement. The Center also has a study involving 16 geographic sources of slash pine. Foresters from industry and other groups collected seed and made outplantings for this study. The Lake City Center is also cooperating with the Athens-Macon Center in a test of loblolly pine races in Georgia and Florida

A slash pine ecotype study has been started to see if there is any difference in progeny of slash pine from wet and dry sites.

Research in techniques of vegetative propagation has been stepped up greatly in the past few years to provide the methods needed to perpetuate superior strains. Rooting of cuttings still is difficult. However, fairly efficient methods were developed by Francois Mergen for air-layering and grafting slash pine.

The Lake City program includes several tests of techniques for managing seed production areas and seed orchards. One test compares 2 fertilizers, 2 rates of application, 2 types of stem injury, and 1 type of root injury with the object of stimulating seed production in 6-year-old and 20-year-old plantations of slash pines.

## THE ATHENS-MACON RESEARCH CENTER PROGRAM

The Station's genetics efforts in Georgia started in 1950, when cooperation was begun with the Ida Cason Callaway Foundation at Hamilton, Georgia. The objective was to produce by selection a superior strain of pine for planting in the middle South.

In local pine stands and plantations, 119 plus trees have been selected. Another hundred or so selections are tentative. Starting in the spring of 1952, one-parent tests have been made with 30 slash, 22 loblolly, 17 shortleaf, and 15 longleaf mother trees. Approximately 27,000 seedlings have been planted. A few plantings have been made of different geographic races of loblolly and slash pines.

Comparisons are made between progenies of plus trees, and between those of plus trees and seedlings of commercial seed. Progeny of some mother trees are growing as much as 35 percent faster than others. Progeny of some mother trees, in tests replicated for 4 years, grow consistently faster than the controls. In slash pine, progeny of wide-crowned mother trees are as much as 50 percent wider at one-third the height of the tree than those from well-formed trees. The controls and two lots of randomly collected slash pine average 86 percent more trees infected by rust than progeny of fast-growing, rust-free trees in a plantation where, at age 15, 75 to 80 percent of the trees were infected. These seedlings have been in the field 3 years and are 6 to 7 feet tall. This year, several acres of seed orchard were outplanted with open-pollinated seedling stock of the better parent trees. Additional seed orchard plantings are

planned with grafted stock and seedlings from control-bred and open-pollinated seed.

In 1954 the Athens-Macon Research Center began a formal forest genetics project in cooperation with the Georgia Forest Research Council and the Georgia Forestry Commission. Laboratory, greenhouse, lath house, and nursery facilities have been constructed by the Commission and Council. Over a thousand "super" seedlings of slash and loblolly pines have been outplanted. Seedlings of 14 Georgia loblolly seed sources and 3 from Florida are being raised for a racial variation study. Seedlings of 15 separate trees of each of 3 sources are being grown for a between-tree variation study in connection with the racial variation study. In addition, a number of superior phenotypes have been selected and open-pollinated seed and grafted stock are being grown.

The Center is giving technical direction to the Georgia Forestry Commission's seed orchard project which has the objective of establishing about 500 acres of grafted slash and loblolly pines from superior phenotypes. In January 2,500 potted seedlings were grafted. About 60 percent were successful at Athens, Georgia, and 80 percent at Macon where we had better humidity control. About 7,500 seedlings were potted this summer for grafting in January and February of 1956.

At the University of Georgia at Athens, forest pathologists of the Southeastern Station are selecting and breeding for resistance to littleleaf disease in shortleaf pine. Six apparently resistant trees growing in heavily infected stands have been selected and grafted to seedling stock. Although one-parent progenies exposed to attack by the root fungus responsible for littleleaf have shown some differences between trees in susceptibility, they averaged less infection than progeny from littleleaf diseased trees. Control-pollinated seed of the selected trees was planted this year. Test plantations of 12 geographic sources of shortleaf pine on severe littleleaf sites in 3 states were established a year ago and are now growing well.

The Athens-Macon Research Center works very closely with projects in forest genetics at the University of Georgia. The School of Forestry has two men working on vegetative propagation and fundamental problems in variation and inheritance as part of the program of the Georgia Forest Research Council. Also, the school has a graduate student part time on a study of variation and inheritance of fiber length in slash pine. This work is a station-supporting subproject under a regional Research and Marketing Act project of the Southern State Agricultural Experiment Stations. Alabama and Texas also have station-supporting subprojects. At the present time I happen to be chairman of the technical committee for the regional project.

A new hardwood management and utilization research project, initiated in 1954 at Athens, Georgia, will have some genetics work in the program--probably studies of variation in wood quality as related to polyploidy.

## TREE IMPROVEMENT STUDIES AT OTHER RESEARCH CENTERS

The Southeastern Station's Tidewater Forest Research Center at Franklin, Virginia, has a one-parent progeny test of the inheritance of stem form in loblolly pine. The progeny are nearly 3 years old. In cooperation with the South Carolina Forestry Commission, the Santee Research Center in South Carolina is testing eight local seed sources of longleaf pine for planting on the droughty soils of the sandhills. The Cordele Research Center in Georgia has a project in the selection of superior slash pine trees, particularly in its many acres of planted stands on the George Walton Experimental Forest. These selections are now being utilized in two of the Station's genetics projects.

The Southern Appalachian Research Center at Asheville, North Carolina, has a cooperative test with the Central States Forest Experiment Station of the performance of planted yellow-poplar of 16 different geographic origins. The seedlings were planted in the spring of 1954. The same research center has a test of six geographic strains of northern red oak that were planted early in 1953, in cooperation with the Cabot Foundation, and a small 20-year-old test of hybrid poplar clones. A plantation of five promising clones of Chinese chestnuts was established in 1953 by the Division of Forest Disease Research. A cooperative study in racial variation in white pine is being arranged with the Lake States, Central, and Northeastern Forest Experiment Stations and other research agencies.

The Division of Forest Insects Research of our Station has been selecting longleaf and slash pines for resistance to black turpentine beetle at Lake City, Florida.

A major accomplishment of the Station was the development by selection and vegetative propagation of wilt-resistant strains of the mimosa tree by the Division of Forest Disease Research. Two resistant, named varieties have been turned over to the nursery trade. This project has now been transferred to the Agricultural Research Service.

Forest insect and disease specialists at both the Southeastern and Southern Stations have joined hands in a thorough annual check of most of the plantations in the southwide pine seed source study. This study involved the collection of seed from 50 sources, production, and shipment of 1,824 lots of stock from 19 nurseries and their establishment in 66 separate plantations in 16 states. About 220,000 seedlings were planted.

In addition to the program in which the Southeastern Station is involved, the University of Florida has a cooperative project in forest tree improvement with forest industries. Foresters of nine companies are selecting superior phenotypes from which scions are to be grafted to wild stock by the University technicians. Also, a number of pulp and paper companies have converted natural stands to seed-producing areas from which to obtain seed for their privately operated nurseries, and their research foresters are conducting studies in the field of tree improvement.

This has been a brief summary of our program in forest tree improvement. Additional details can be obtained from publications and annual reports of the Southeastern Forest Experiment Station.

## PROGRESS IN TREE IMPROVEMENT RESEARCH AT THE SOUTHERN FOREST EXPERIMENT STATION

Philip C. Wakeley and Berch W. Henry[1/]

The territory of the Southern Forest Experiment Station extends from Tennessee, Alabama, and the 10 westernmost counties of Florida through the western limits of the southern pine types in Oklahoma and Texas. Throughout most of this territory timber production is, potentially or actually, the dominant land use.

Throughout most of it, also, the potential benefits of applying the findings of forest genetics research are enormous. These potential benefits include increased quantities and quality of products from good to excellent sites in many pine types, and in the bottomland hardwood types of Mississippi, Arkansas, and Louisiana. They include also the partial or complete solution of many local or special problems, of geographic sources of seed for an annual planting program of a quarter of a billion trees, of the delayed initial height growth of longleaf pine, of brown spot needle blight of longleaf pine, of the fusiform rust of slash and loblolly pines, of such insects as bark beetles and Nantucket tip moth, and of special stock for poorly drained areas, deep, excessively drained sands, and areas of frequent, severe droughts.

Opportunities both for genetic research and for application of results could hardly be excelled.

Eight species of hard pines are native to the territory. They exhibit a high degree of individual variation--much more than red pine seems to, for example. At least three exhibit great racial variation as well. Considerable hybridization among them has proved possible through artificial crossing. Among hardwoods, yellow-poplar is of interest because of its high value and very wide occurrence, and cottonwood because of its fast growth, high value, and easy vegetative propagation. The breeding potentialities of the oaks, both bottomland and upland, and of many other hardwoods, are anybody's guess.

A pine planting program which, despite its annual expansion since World War II, still has many millions of acres to cover, offers an ideal outlet for almost all positive findings of genetics research on pines Intensive management of natural stands, particularly by the pulp industry,

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1/ Respectively, Forester at New Orleans, Louisiana, and Head, Southern Institute of Forest Genetics, Gulfport, Mississippi, Southern Forest Experiment Station, Forest Service, U. S. Department of Agriculture. This paper was read by Dr. Henry.

offers an even wider outlet for findings applicable through natural reproduction.

The progress in tree improvement made by the Southern Forest Experiment Station in the midst of these obvious opportunities is hard to evaluate objectively. Our current program was launched in 1950, but remained on a very limited basis until 12 months ago. Nevertheless, we feel that we have been successful in certain essential steps. Also, we have a legacy of test plantations, individual trees, records, and experience going back to the period 1925-1937, which promises to save us at least 20 to 30 years in some of our most important current studies, particularly at the recently created Southern Institute of Forest Genetics.

## SCOPE AND OBJECTIVES OF THE PRESENT PROGRAM

At its Research Centers, and in cooperation with other federal, state, and private agencies, the Station is studying racial variation in southern pines, selection and breeding of pines and cottonwood, and interspecific and interracial hybridization of pines, together with pollination and other techniques essential to these studies.

Three main concepts have guided the Station in planning its forest genetics research:

First, for best results, both selection and hybridization must be done within the framework of existing geographic races. Improved trees for the deep sands of western Florida or the low-rainfall belt of eastern Texas must be produced from locally adapted parent stocks, rather than from some single convenient sources such as eastern Louisiana.

Second, the Station does not aim primarily at the discovery, designation, multiplication, and distribution of genetically improved plant material. Rather, it seeks to acquire and make available the soundest possible knowledge of the mechanism of inheritance in the species concerned, and of how to manipulate it, so that not only the Station, but others also, may improve trees for the widest possible variety of conditions and uses.

Third, results applicable through natural reproduction are sought equally with those applicable only through planting. The maximum possible benefit per acre attainable through natural reproduction may be less, but, because of the vastly greater acreage likely to be regenerated naturally, the total gain may be as great or greater.

## THE SOUTHWIDE PINE SEED SOURCE STUDY

The Southern Station is the Chairman organization of the Subcommittee on Geographic Source of Seed, of the Committee on Southern Forest Tree Improvement. In this capacity it launched in 1951 a cooperative study designed to map the zones within which seed of loblolly, slash, longleaf, and shortleaf pines, respectively, might safely be moved from collecting ground to planting site, but across the boundaries of which seed should

not be moved. Through the subcommittee's offices as coordinator, cooperators in 16 states have planted stock from 61 seed sources in 66 test plantations totaling 1,824 individual plots, or more than 220,000 trees. The loblolly and slash pine plantations have survived well enough to meet the needs of the study. Deficiencies in the longleaf and shortleaf phases of the study, resulting mainly from the 1953 and 1954 droughts, are scheduled for correction by further plantings with stock from 1955 seed.

## THE SOUTHERN INSTITUTE OF FOREST GENETICS

About a year ago, the Southern Institute of Forest Genetics, an integral part of the Southern Forest Experiment Station, was established at Gulfport, Mississippi. It replaces the former Gulfcoast Branch of the Southern Station.

The staff consists of six technical men, including a pathologist and an entomologist, and their assistants.

Along with selected studies inherited from the previous establishments in forest management and forest pathology, the Institute is conducting both basic and applied research aimed at improving the quality and quantity of forest trees of the South. The emphasis is now on the southern pines.

Current work includes studies on variation among individuals of a race, among races of a species, and among species of southern pines, and the extent to which certain desired characters, including resistance to the fusiform rust and brown spot diseases, are inherited; studies on the interspecific compatibility of the southern pines; studies on flower production and on pollen extraction, germination, and storage; morphological studies on the life cycle of longleaf pine, and the pathological anatomy of the fusiform rust on slash pine; and the effects of nursery practices on survival and growth of outplanted stock. Of necessity, the entomological work at present is aimed largely at control of cone insects and plantation insects; resistance studies are planned for later.

## STATION RESEARCH OTHER THAN AT THE INSTITUTE

The main genetics research effort, other than at the Institute, has been at the Crossett, Arkansas, Research Center, where one man has been maintained, full time, on cooperative funds, since the fall of 1952. Studies at Crossett, in addition to two test plantations of the Southwide Pine Seed Source Study, include selection of and breeding on loblolly plus trees, nursery selection of loblolly and shortleaf seedlings, a unique local seed source study, considerable interspecific and some interracial hybridization, and preliminary work on development of seed orchards.

The Alexandria, Louisiana, Research Center did some effective hybridizing in 1951, and has cones coming from new crosses made in 1954 and 1955.

It has valuable breeding stocks of 44 seed sources of 4 species of southern pines, now 19 years in plantation, and 1 very promising brown-spot-resistant longleaf pine discovered in an abandoned nursery in 1937 and now bearing seed.

First attempts to breed pines especially adapted to the deep sands of western Florida were made at the East Gulfcoast Research Center, Marianna, Florida, in 1955. Longleaf and sand pine seed sources are also under test at this Center.

The Delta Research Center at Stoneville, Mississippi, began selection studies of cottonwood in 1954, and three other Centers situated in pine-hardwoods types have various tests of hybrids, of geographic sources of seed, or both.

The Station has enjoyed productive cooperation in hybridizing, selection, and development of pollination techniques with A. J. Hodges Industries, Inc., at Many, Louisiana, where the company is developing a private institute for game management and forest genetics research, with a full-time technical man, an assistant, plenty of labor, and excellent physical facilities. The Station is also cooperating with the Biophysics Laboratory of Tulane University and the Botany Department of Newcomb College (both in New Orleans) in irradiation of seed and in anotomical studies of the development of longleaf "flower" primordia, respectively.

## RESULTS TO DATE

The program just described has been under way too short a time to yield many definite results. The following releases and publications, however, may be of interest as a sample of what may be expected in the future.

Bercaw, T. E.
1955. Progress report on loblolly seed source study at Bogalusa. Third South. Conf. Forest Tree Improvement Proc.: 25-30, illus. (Processed.)

Henry, Berch W., and Coyne, J. F.
1955. Occurrence of pests in southwide pine seed source study. Third South. Conf. Forest Tree Improvement Proc.: 49-54. (Processed.)

Sihvonen, Sulo
1955. Study of seed source in reverse. Third South. Conf. Forest Tree Improvement Proc.: 13-16. (Processed.)

Wakeley, Philip C.
1951. Proposal for a cooperative study of geographic sources of southern pine seed. South. Forest Exp. Sta. 16 pp. (Processed.)

_______ 1951. Standardized working plan for local tests of seed source. South. Forest Exp. Sta. 11 pp., illus. (Processed.)

_______ 1952. Working plan for cooperative study of geographic sources of southern pine seed. South. Forest Exp. Sta. 35 pp., illus. (Processed.)

_______ 1953. Progress in study of pine races. South. Lumberman 187(2345): 137-140, illus.

_______ 1954. Geographic source of seed. U. S. Dept. Agr., Agr. Monog. 18: 14-16, illus.

_______ and Campbell, Thomas E.
1954. Some new pine pollination techniques. South. Forest Exp. Sta. Occas. Paper 136, 13 pp., illus. (Processed.)


## CURRENT FOREST TREE IMPROVEMENT RESEARCH IN THE CENTRAL STATES

G. A. Limstrom[1/]

When I attended the first Lake States Forest Genetics Conference 2 years ago, I could not help noting the enthusiasm and earnestness of the participators in getting a sound tree improvement program under way. Today I see this same enthusiasm and earnestness, and from reports I have read I know that considerable progress has been made during this brief period.

Foresters in the Central States are interested in the work you are doing and plan to do in the Lake States in the field of forest genetics. It may surprise some of you to know that in 1954, typical of recent years, more than 45,000 acres were planted to trees in the Central States. The bulk of this planting is pine, and a good percentage of it includes pine species native to the Lake States. Faced with this demand for coniferous planting stock in a region where few of these species occur naturally, we must depend on cooperators in states to the south, east, and north of the region for seed.

Natural hardwood stands are the dominant forest cover in the region, however, and many hardwoods are planted each year. Our forest tree improvement research program, then, must include studies in the improvement of existing natural stands as well as the selection of high-quality trees--conifers and hardwoods--for reforestation projects.

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1/ Forester, Central States Forest Experiment Station, Columbus, Ohio. Forest Service, U. S. Department of Agriculture.

Before describing the current tree improvement projects, I should briefly list some of the completed studies which have been helpful in the current program. While at the Purdue University Agricultural Experiment Station, Wright made some rather comprehensive studies of racial variation in white ash and black walnut. At the same institution, Wean and Guard have contributed much to our knowledge of the seeding habits of yellow-poplar, and Carpenter obtained much better germination and development of seedlings by cross-pollination of this species than that obtained by natural, or wind pollination. Working with the Tennessee Valley Authority, Chase reported better nuts and wood from the Thomas black walnut than from native walnut trees. He also reported partial success in rooting black locust cuttings. Henry Hopp, of the Soil Conservation Service, reported definite growth-form variations of black locust. There have no doubt been other studies in the past which I have unintentionally overlooked.

In connection with work on the Dutch elm disease and phloem necrosis, the Agricultural Research Service is making a thorough search for resistant strains and species of this genus. One variety, the Buisman elm, appears very promising.

The Ohio Agricultural Experiment Station has an important program under way in forest genetics. Although initially restricted to sugar maple, work with other important trees, such as oaks and pines, is contemplated. The sugar maple study, undertaken by Kriebel, consists of two parts--one concerned with increasing the yield of syrup, the other concerned with wood quality and growth rate. To date, the study of geographic variations in sugar maple is the most significant aspect of the project; some 40 seed sources have been sampled, and observations of both physiological and morphological differences are being made. A detailed report of the responses of seedlings and small saplings will be prepared in the near future.

During the past 10 years the Central States Forest Experiment Station has begun a number of provenance studies and has collaborated with other agencies in field tests of various hybrids. A large number of species are included in these experiments.

## JACK PINE

In the spring of 1954 2-0 jack pine seedlings from 17 different sources in the Lake States were planted in a number of locations in Indiana. Seed for this study was obtained largely from the Lake States Forest Experiment Station from some of the sources used by that Station for similar studies. With cooperation from the Indiana Department of Conservation and Purdue University Agricultural Experiment Station, the stock was produced at a state nursery and planted on old fields and strip-mined lands in the northern and western part of the state.

## SHORTLEAF PINE

Two separate experiments, testing various geographic sources of shortleaf pine, have been established. One of these, which included stock from seed of pine from widely scattered locations, was established on old-field sites in southern Illinois in 1949; the other, using seed from seven different sources, was planted in the Missouri Ozarks and was established in cooperation with the Southern Forest Experiment Station in 1953.

## LOBLOLLY PINE

Two separate loblolly pine source-of-seed experiments, one in 1949 and the other in 1950, have also been established in southern Illinois. The 1949 tests are independent studies and include stock from seed of seven sources. The 1950 tests, made in cooperation with the Tennessee Valley Authority, include stock from seed of different sources. Taken together, the results of these tests will serve as good checks on the reliability of tests for geographic sources. We have already noted differences in resistance to frost among several sources.

## WHITE PINE

At the suggestion of the Southeastern Forest Experiment Station, a rather comprehensive white pine source-of-seed study is being planned. The Lake States and Northeastern Stations, as well as the Ontario Department of Lands and Forests in Canada, will also participate in the experiment. Working plans are in preparation, and we are now making the seed collections.

## PINE HYBRIDS

Since 1949 a number of pine hybrids developed at the Institute of Forest Genetics, Placerville, California, have been field tested in southern Illinois. These include crosses and back-crosses of pitch and loblolly, and shortleaf and loblolly pines, planted on old fields in southern Illinois. To date none of the hybrids has been superior to interplanted shortleaf or loblolly pine in either survival or growth.

## EASTERN REDCEDAR

An eastern redcedar source-of-seed experiment was also established in southern Illinois in 1951. Eight different sources of seed are being tested. Two of the four blocks planted have already been partially destroyed by fire. Survivals on the unburned blocks have ranged from 14 to 97 percent, and the average heights for the third year in the field range from 1.5 to 2.4 feet.

## BLACK LOCUST

For this species we are concerned mainly in a selection that is resistant to the locust borer. Some of the early selections planted in the thirties have developed into good stands; so few of these have been found, however, that they furnish leads only for further testing. Two of the well-known locations of existing selection plantings are at Zanesville, Ohio, and Beltsville, Maryland. Six new selections are being propagated at our Columbus laboratory; the latter were obtained from Dr. W. W. Steiner of the Soil Conservation Service, Beltsville. His strain No. HC-4138 is smooth-barked and grows rapidly; it is expected to suffer less from borer attack than other strains, as the borers prefer to lay their eggs in deep bark crevices.

## CHESTNUT

During 1952 and 1953, in cooperation with the Agricultural Research Service, we out-planted a number of blight-resistant strains of Chinese chestnut in Missouri and Illinois. Growth and survival in both locations have been fair, but existing natural vegetation is so luxuriant that frequent release cuttings will be necessary to maintain good development of the chestnut trees.

## POPLAR HYBRIDS

In cooperation with the Northeastern Forest Experiment Station, we are continuing to study the use of hybrid poplars in the reclamation of strip-mined land. In 1951, 50 clones were planted on two different sites in eastern Ohio. Results have not been conclusive to date because the response of each clone has varied considerably among replicates.

Recently two clones of a natural hybrid of white poplar and bigtooth aspen have been found in Iowa. Both are fast growing, and one has wood of an attractive, wavy figure. The classification and nomenclature of these clones is now in the process of publication. Both can be reproduced easily by vegetative propagation. Cuttings of each, along with others from the University of Wisconsin and the Province of Ontario, are being field planted to compare growth and wood quality.

## WHITE OAK

Epicormic branching of white oak is a problem that must be considered in stand improvement work. Current silvicultural experiments are designed to determine the effects of thinning, pruning, growth rates, stand density, and crown classes on the extent of epicormic branching. In addition to these studies, we are planning to begin experiments to study the role of heredity on the character and extent of epicormic branching.

## YELLOW-POPLAR

In 1952 we began a study of yellow-poplar seed sources. Seeds were collected from 13 locations well distributed throughout the range of the species. The first field plots were established in the spring of 1954 in Ohio, Indiana, and Illinois. In addition to the usual stand-source experiments, we are testing the progenies of individual seed trees within each stand, and are attempting to find seedling characters of genetic significance. In the same experiment separate studies are being made to test effects of nursery practices on seedling quality, and to determine the effects of three different seed years on seed and seedling quality.

# FOREST TREE BREEDING IN CANADA
## REPORT FOR SECOND LAKE STATES FOREST TREE IMPROVEMENT CONFERENCE

Mark J. Holst[1/]

An excellent report on "Forest Tree Breeding in Canada" was prepared by Dr. C. C. Heimburger and published in the Forest Tree Improvement Issue of the Journal of Forestry 52(9): 682-685, September 1954. I shall briefly summarize the tree breeding activities in Canada by workers and localities, and if time permits, I shall discuss a few tree breeding problems of mutual interest to Canada and the Lake States.

W. A. Porter, who is employed by the Canada Department of Agriculture, is selecting western white pine for resistance to blister rust, and Douglas-fir for possible resistance to *Rhabdocline pseudotsugae*.

A. L. Orr-Ewing is employed by the British Columbia Forest Service and is studying flowering and fruiting of Douglas-fir as a basis for establishing seed orchards.

In the prairie Provinces we have W. H. Cram at the Forest Nursery Station, Indian Head, Saskatchewan, a branch of the Canada Department of Agriculture. Dr. Cram is concerned chiefly with selection of superior tree and shrub material for shelterbelts and windbreaks in the prairies. He is working with caragana, spruces, Scots pine, and poplars.

Dr. C. C. Heimburger, who is employed by the Ontario Department of Lands and Forests and stationed at the Southern Research Station, Maple, Ontario, is working with white pine, aspen, and hard pines. The aim of the white pine work is to select and produce strains having a high degree of resistance to blister rust and a favorable reaction pattern in respect to weevil injury, and satisfactory growth rate and form. The white pine provenance problem is also being investigated. The aim of the aspen breeding program is to produce strains with rapid growth, resistance to several

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1/ Research Forester, Petawawa Forest Experiment Station, Canada Department of Northern Affairs and National Resources, Chalk River, Ontario.

important diseases, and which will be easily propagated from cuttings. The material is to be used in southern Ontario.

A. J. Carmichael, who is employed by the Ontario Department of Lands and Forests, and stationed at the Provincial Seed Extraction Plant, Angus, Ontario, is conducting provenance experiments with white pine, red pine, and jack pine, and various exotic pines. He is also multiplying the material selected by Dr. C. C. Heimburger to establish seed orchards. He is furthermore selecting and propagating yellow birch.

J. A. C. Grant is employed by the University of Toronto. He is studying the photoperiodic responses of aspen, hard pines, and spruce.

Dr. A. W. S. Hunter is employed by the Canada Department of Agriculture and is working at the Central Experimental Farm in Ottawa, Ontario, and the Dominion Experimental Station, L'Assomption, Quebec. He is breeding for resistance to Dutch elm disease, and he has provided sterile, blister rust susceptible currants for Dr. C. C. Heimburger's white pine breeding projects.

Dr. R. J. Moore is employed by the Canada Department of Agriculture and is working at the Central Experimental Farm in Ottawa. He is doing cytogenetic studies in Caragana.

Dr. L. Chouinard is giving lectures in forest genetics at the School of Forestry, Laval University, the first of this kind in Canada. He is working with air-layering of native tree species and has planned population studies in black spruce, red spruce, and jack pine in Quebec.

M. J. Holst is employed by the Forestry Branch, Canada Department of Northern Affairs and National Resources, and is working at the Petawawa Forest Experiment Station, Chalk River, Ontario. The work is centered on Canada-wide provenance studies of native spruces and hard pines, and selection and propagation of plus trees of native spruces and hard pines in a more limited area--the Great Lakes-St. Lawrence Forest Region. The white spruce work in this region is done in cooperation with the Canadian Pulp and Paper Association. The tree breeding work at the Petawawa Forest Experiment Station includes also a variety of projects such as: provenance experiments in, and selection of, exotic spruces and hard pines; breeding of hard pine types resistant to the European pine shoot moth (in cooperation with Dr. C. C. Heimburger); breeding of the perfect Scots pine Christmas tree; selection of larch; breeding for weevil resistance in Norway spruce; investigations of flower-inducing techniques for spruces and hard pines; population genetics of native conifers; and various experiments with propagation, mainly grafting.

At the Acadia Station in New Brunswick, H. G. MacGillivray is doing provenance experiments with red and black spruces, and is also studying introgressive hybridization of these species in New Brunswick; he is furthermore selecting balsam fir for resistance to spruce budworm.

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# REPORT OF THE NORTHWEST FOREST GENETICS ASSOCIATION MEETING

Roy R. Silen[1]

The first official meeting of the association was held at the Weyerhaeuser Timber Company offices at Centralia, Washington, on June 13, 1955. Twenty-one representatives of the industry, colleges, and state and federal research organizations attended.

Temporary chairman, Leo Isaac, covered the essentials discussed by a smaller organizing group at Portland in February. He reviewed the needs expressed there for an informal organization among workers in the field to exchange ideas and disseminate information but not to become a policy-making body.

First business was the nomination and unanimous election of J. W. Duffield as chairman.

A discussion of sponsorship for the association followed. Several members reviewed the experiences of the sponsorship of similar organizations such as the nursery, soils, and seed committee. Agreement was reached that the association should go unsponsored.

Next business was a long and lively discussion on setting up a central plus tree registry. Practically everyone participated. No formal motions were introduced, but some definite conclusions were agreeable to all. The discussion was very informal and is best summarized by subject matter.

## DISCUSSION OF PLUS TREE REGISTRY

### Location

This began as one of the major points of disagreement, but the problems ironed out in the discussion. General consensus was for each organization to keep its own registry, but that copies of the standard registration form be sent to the Experiment Station in Portland where a region-wide central registry would be kept.

### Standard Report Form

Both Duffield and Isaac proposed detailed registration forms which they had independently developed. Isaac's stressed major tree characters, and Duffield's stressed location. Much general discussion on the need for a uniform system followed. Since both forms were essentially similar and

1/ Secretary, Northwest Forest Genetics Association. Mr. Silen is a research forester with the Pacific Northwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Portland, Oregon. In Mr. Silen's absence this paper was read by R. G. Hitt.

not greatly different from an earlier published draft, it was agreed that Duffield and Isaac get together in providing the association with a standard form.

## System of Reporting

Samples of the report form will be mailed to the membership. The procedure decided as most satisfactory was that each organization make copies of the form under its own letterhead, and set up administrative details of reporting. Enough copies of the report for each tree would be made to fulfill the needs of the organization and to send copies to the central registry.

## Species

At least for the present, two registers, 1 for Douglas-fir and 1 for ponderosa pine, were set up. Registers for other species were considered, but no decision reached except that they would be added as demand for them grew.

## Kind of Trees

It was generally agreed any tree having an unusual or plus character should be reported for the register, and not just the outstanding trees. The danger of too many trees being reported was subject to much comment, but the group seemed to favor not being too selective in the beginning. Isaac, with figures on possible workload, indicated that less than 400 trees have been registered to date in Sweden where such work is very advanced.

## Vandalism

Question of protecting plus trees was brought up by several members. Opinions ranged from the belief that vandalism would never be a problem all the way to the suggestion that owners should not report trees that could not be protected. No agreement was reached.

## Rating Schemes

Various possible tree character rating schemes were aired but nothing was settled. Dingle suggested application of the ratio of crown width to length of top 10 internodes. Isaac proposed a numerical rating scheme and produced drawings to illustrate some of the tree characters in the scheme. Cummings suggested studies of the variability of individual tree characters. Silen added the suggestion that such studies be started first on open-grown trees. This could serve as a yardstick for comparison with reported plus trees to see if they were doing better than could be accounted for by environment alone.

## Rating Boards

A board of association members for rating plus trees was suggested as desirable since seed and scions of such trees would begin to have enhanced value even before the progeny tests were made. Duffield illustrated a concept of this value as:

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|---|---|
| X | = value after registration as plus tree |
| 1 to 5 X | = value after good performance as a clone |
| 10 to 50 X | = value after good performance in progeny test |

Isaac further amplified this by citing prices of $100 per pound for seed from certain plus trees in Sweden.

Opinions varied greatly as to the desirability of taking on this service. Further discussion was tabled as a subject for some future meeting.

Chairman Duffield asked that the Oregon State Douglas-fir provenance study be moved forward on the agenda to allow ample time for a full discussion. He explained that the Oregon State Board of Forestry men had requested that time be set aside during the meeting since most of the agencies cooperating in the study were represented. The meeting was turned over to Dale Bever.

## OREGON STATE BOARD OF FORESTRY DOUGLAS-FIR PROVENANCE STUDY DISCUSSION

Bever first discussed the past work and present status of the study. Enough areas for starting the study have been provided by cooperators. Questions had arisen regarding details of seed collections this fall. Some cooperators had asked if collections from individual trees should be kept separate. This was not planned in the original study, Bever explained. The only restrictions on seed collections were that the sample come from a minimum of 50 trees within a radius of 25 miles and at the same elevational zone as the provenance plantation.

A main issue brought up by these rules was whether cone collections could be made at any point within the 25 miles, or if each must be spread over the 25 miles to meet the condition of homogeneity of variance within samples. A similar question arose as to whether seed could be collected from any slope and any type of tree, or must be collected from all slopes and types of trees. Whether or not seed from infected trees should be used was also asked. There was wide diversity of opinion over these points.

Questions also arose as to the location of the plantations. Discussions revolved around the arbitrary choice of north slopes which put the northernmost plantations out of the Douglas-fir type. A suggested alternative was to use very gentle slopes of any exposure to give more similar conditions. Needs for additional plantations to fill the gap between 600 feet and 1,800 feet elevation were discussed. Cornelius made a plea that

fencing of the plantations be undertaken by the cooperators wherever they were needed.

Concerning the analysis, a suggestion was made that the plan be reviewed by another statistician. The possible advantage of sowing part of the seed in another nursery was suggested also. Someone mentioned the precaution to avoid collecting seed from the study in old plantations. It was generally agreed that seed lots be stored until all collections were completed rather than start the study in parts.

Bever promised that a detailed set of instructions for seed collections and locating the plantations would be mailed to all cooperators this summer. He also asked for more cooperators in the study.

Chairman Duffield tabled the report of activities from each organization until the next meeting, and the meeting adjourned.

## FIELD TRIP, JUNE 14, 1955

The genetics association met at the Forest Industries Tree Nursery at 9:00 a.m. for a brief showing of the nursery, rooting, and grafting tests by Duffield. Next stop was the McCleary Experimental Forest. The Swedish aluminum ladder and Swiss tree climbing gear were demonstrated. Group discussion centered around two candidate plus trees chosen prior to the meeting.

The group then went to the King Creek Tree Farm of the St. Paul and Tacoma Lumber Company. Highly successful outdoor grafting experiments were shown by Bent Gerdes. These tests extended over 3 seasons. Another area having a 30-year-old stand was displayed where maximum variability of tree form had been found. The group concluded the meeting by visiting a nearby candidate plus tree.

## THE FORESTRY RESEARCH SURVEY IN RELATION TO TREE IMPROVEMENT

Frank H. Kaufert 1/ 2/

The year 1953, the 25th anniversary of the McSweeney-McNary Act of 1928, presented a suitable occasion for a re-examination of the whole structure of forestry research programs. Accordingly, the Society of American Foresters began a study of forestry and related research in North America during that year. The study was conducted by Frank H. Kaufert (University

1/ Director, School of Forestry, University of Minnesota, St. Paul, Minnesota.

2/ Dr. Kaufert did not prepare his banquet address in manuscript form. The gist of his talk is presented, however, by excerpts taken by the editor from "Forestry and Related Research in North America," by Frank H. Kaufert and William H. Cummings, 280 pp., Society of American Foresters, 1955.

of Minnesota) and William H. Cummings (University of Michigan) under general supervision of a 5-man steering committee selected jointly by the Council of the Society of American Foresters and the Division of Biology and Agriculture of the National Research Council. A grant of funds by the Rockefeller Foundation, New York, N. Y., made the project possible.

Results of the survey, published this year by the Society, cover the whole field of forestry and related activities. Here, however, we are concerned particularly with findings concerning forest tree improvement.

"In this survey, forest genetics research was considered to include all work dealing with (1) basic inheritance and cytology studies on forest trees; (2) the production of superior trees for planting through such processes as selection, hybridization, and induction of polyploidy; and (3) the development of techniques for the genetic improvement of naturally reproduced stands. Probably, the term 'forest tree improvement research' would more nearly define the field covered by this report.

"Research in forest genetics is expensive. Little progress can be expected unless more adequate financing is provided. Large immediate increases in funds could lead to waste, however, because there is a serious shortage of well-trained personnel. Doubling the funds available within the next 3 to 4 years, and a gradual increase to about 12 times the present expenditures of $400,000 to about $5,000,000 in 1978, should provide adequate financing for this program. The cost of breeding and improvement programs on such agricultural crop plants as cotton and corn is now in excess of $5,000,000. Should we consider spending less than this for all of the forest genetics work needed on the more important commercial species with products valued at about $13,000,000,000 annually?

"The nature of forest genetics research is such that public agencies will need to continue responsibility for the major part of future research. Forestry schools and other research groups associated with institutions possessing strong plant breeding staffs are logical centers for developing experimental work in forest genetics. Endowed institutions have made many contributions in fundamental forest genetics research, and should be encouraged to expand their programs for they appear to be the group in the best position to undertake some of the long-time basic studies so urgently needed.

"All agencies, including industries, should participate in the necessary expansion of provenance studies. This research should be under the direction of research workers, but it requires the cooperation and participation of practicing foresters if it is to be expanded to the extent needed. Such studies offer the greatest promise of early results of practical value, and most of the improvement in forest trees in the next century are expected to come from seed-source studies rather than from hybridization.

"Fundamental studies of hybridization, seed production, and genetic analysis should be concentrated at adequately staffed and financed research centers. Public agencies and interested industries should pool their resources in such centers rather than engage in fragmentary efforts. Too many poorly organized and underfinanced research starts have occurred in the past. The long-term nature of these studies, the fact that they are expensive, and that highly skilled and well-trained personnel are required must be recognized by everyone planning to engage in tree improvement research.

"Enthusiasm is easily developed regarding possible accomplishments through forest genetics research. Enthusiasm and optimism are essential, but they must be strongly linked with realism. It is the obligation of research workers to inform foresters of the problems as well as potentialities of forest genetics research.

"To provide a larger number of well-trained research workers in this field, more fellowships must be made available for graduate students. Industries interested in forest genetics can make their greatest contribution by providing fellowship funds that would stimulate students to obtain training in genetics and physiology. In this field in particular, such contributions would have far more significance than attempts by industrial foresters to engage in tree breeding work as a sideline.

"Forest geneticists must work in close cooperation with wood technologists, pathologists, entomologists, physiologists, ecologists, economists, and silviculturists if the results of their work are to find eventual application."

## BOTANICAL ASPECTS OF POLLEN AND SEED COLLECTION

Scott S. Pauley[1/]

According to various authors of articles published in recent years, the first artificial hybridization of pine species is said to have been accomplished and reported by a German worker about 100 years ago. Dr. J. W. Duffield has informed me that he had the opportunity recently to consult the original article reporting this work, and his translation turned up a most interesting and significant point.

In the account of the method used, the author states that in the spring of the year he collected the pollen of one species of pine and applied it to the receptive female strobili of another species. He then goes on to say that in the autumn of the <u>same</u> year he extracted the hybrid seed from the carpellate cones.

1/ Associate Professor, School of Forestry, University of Minnesota, St. Paul, Minnesota.

Since it is a well-established morphological fact that pines require 2 years to mature their cones, the conclusion is inevitable that hybrid seed could not possibly have been harvested in the same year that the pollinations were made. And, needless to say, the worker concerned employed a labeling method that cannot be recommended.

Although this is a somewhat extravagant example, it does serve to emphasize the self-evident fact that workers concerned with the manipulation of tree pollen and seed must possess something more than a superficial botanical knowledge of the plants with which they work.

In this day and age I have no doubt that those investigators directly engaged in tree improvement studies are intimately familiar with the taxonomic and morphological characteristics of the species with which they work. But this very familiarity may frequently in itself lead to delays and errors through a failure to recognize that others, especially cooperators outside the botanical fields, usually do not have the specialized and detailed botanical knowledge of a species or genus that the worker may possess.

I recall that one of Bill Cheyney's favorite stories concerned an old pulpwood operator in northern Minnesota who had spent most of his active life cutting spruce. One day in late spring Cheyney visited him on one of his cutting operations, and the logger showed him several small immature female cones he had picked from the terminal portion of the crown of a felled spruce. He said that he had seen these things on spruce from time to time for the past 30 years and wondered what kind of "bug" caused them.

During the past several years I have had occasion to request seed collections of quaking aspen from a considerable number of foresters in the state and federal services. One of the early and unforeseen results during the first year was the receipt of a surprisingly large percentage of male catkins which had been laboriously collected from the ground. Accompanying notes in some cases explained that late frosts had apparently killed the fruits at an early stage which explained their small size and lack of seed. Others were downright and frankly doubtful that they had collected the right material.

I am pleased to report that almost without exception highly suitable material at the correct stage of development was eventually obtained from all such collectors in a subsequent year. I learned, however, that it pays to provide explicit instructions since the less showy flowers and fruits of woody plants are, as a rule, unfamiliar to those foresters without special taxonomic or morphological interests. Incidentally, the problem of providing an accurate description of female catkins at the proper stage of development for collection was solved by simply mounting herbarium specimens of the catkins on 3x5-inch cards and enclosing them with the request letters.

I might mention in passing that the aspen seed requests turned up some rather interesting information on the question of the frequency with which the Rocky Mountain form of quaking aspen produces seed. Early replies to some of my seed request letters to ranger stations in the West reaffirmed the popular impression that Rocky Mountain aspen simply doesn't produce seed or, if so, only at infrequent intervals. I was therefore advised that there was no point in looking for seed. Nevertheless, I was successful in getting most of the potential cooperators to check on the matter at firsthand. As a result, a considerable number of collections were made the first year. Subsequently, over a 4-year period, several seed collections were obtained from each of the western states in which the species occurs. The idea that the western form of aspen is fruitless is apparently most prevalent in the southern Rockies where it occurs at elevations of 9,000 to 10,000 feet. At these elevations the trails are not opened until well after the flowering period, and even thereafter visitors are few and far between. Largely for this reason, I think, plus the fact that root suckering is an obvious and important method of propagation, the idea of aspen sterility in this region was early developed and has long persisted.

With reference to pollen collection, I should like, in closing, to make brief reference to a method of flower forcing which I think has much promise for coniferous species and those hardwoods the flowers of which cannot be forced successfully on cut twigs in the greenhouse.

Since it is frequently necessary to obtain pollen from a proposed male parent in the field in advance of the receptive period of the proposed female parent, a method of field forcing has very definite usefulness. Conversely, it may also be desirable to force female flowers under field conditions.

Early in the spring of 1953 we successfully forced a female bigtooth aspen into receptivity about 2 weeks ahead of schedule by simply covering a portion of the crown with a black tent made of a windproof rubberized material. The tent served as a heat trap, and the enclosed female flower buds developed well in advance of the uncovered buds. Our objective in this particular case was to effect a cross in the field between bigtooth and quaking aspen, the flowering times of which are separated by a 10- to 14-day interval. The cross was, in fact, effected.

Although I am not aware that this technique has been applied to conifers, I see no reason why it should not prove equally successful. In those cases where female strobili are concentrated in the tip of the crown, as in spruce, special conical tents could be easily prepared and applied. By this method crosses might be effected without recourse to bagging since pollination would be possible well before the air became contaminated by undesired pollen. Similarly, such a tent applied on lower branches in the crown could be used to force development of the male strobili.

# PROBLEMS OF SEED AND POLLEN COLLECTION, SHIPMENT, AND STORAGE

Hans Nienstaedt[1/]

Seed collection is a subject familiar to all foresters and one which usually presents few problems. Some of you, however, may have had little opportunity to become acquainted with the techniques of handling pollen. For these reasons I shall touch very briefly on the first phase of my subject and then devote the remainder of my time to a discussion of the problems connected with pollen collection, storage, and shipment.

## SEED COLLECTION AND STORAGE

When collecting seed for genetics work it is important to remember that extraneous factors may influence the results of progeny testing; hence, the effects of these factors must be kept at a minimum. Requests for cooperation in the collection of seed should be accompanied by recommendations for the handling of the collections; these recommendations should be followed as closely as possible. Between the time of collection and germination, seed quality can be affected markedly by extraction, cleaning, and storage treatments. The more these modifying effects can be controlled, the better. Generally speaking, therefore, the most desirable procedure is to have the seed extracted, cleaned, and stored by one agent.

Seed storage techniques have been worked out for a considerable number of species, and improvements are being developed all the time. Seed of many tree species can be stored for 1 or more years with little loss of viability if they are held in sealed containers at temperatures between 34° and 50° F. Recently it has been shown that seed of Douglas-fir, some pines, and other species can be stored in canvas bags if temperatures are kept well below freezing. With temperatures about 0° F., the seed was stored for 3 years with little loss of viability; storage at 12° and 25° F. gave considerably poorer results. It is probably safe to say that satisfactory storage conditions can be developed for seed of most species.

## POLLEN COLLECTION AND STORAGE

For pollen extraction, the usual procedure is to collect flowering branches shortly before the pollen is shed in nature and to force and clean the pollen indoors prior to shipment. Tree breeders have developed fairly elaborate equipment for these procedures; but when only a few relatively small samples are being handled, the only equipment necessary is some clean sheets of brown wrapping paper, a glass jar with water, a couple of small vials, and a small piece of cheesecloth. The work should be done in a heated room with as little air circulation as possible. The

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1/ Geneticist, Lake States Forest Experiment Station, Forest Service, U. S. Department of Agriculture, maintained at St. Paul 1, Minnesota, in cooperation with the University of Minnesota.

cut branches with flowers are placed in the jar of water on the brown paper. After some time the anthers open, and when the branches are tapped lightly the pollen will drop on the paper. It is then transferred to a vial. The vial is covered with a double layer of cheesecloth, and the pollen is shaken out on a clean piece of paper. Passing it through the cheesecloth once or twice should clean it sufficiently for shipping.

Any small, clean glass bottle, vial, or test tube can be used for shipping. Such containers should be closed with a cotton plug and not with a rubber stopper or cork. I have found it best to furnish cooperators with shipping containers and vials. A short piece of a 2x4 with holes drilled to fit the vials (20x70 mm.) makes a handy shipping kit. Sometimes a small amount of "Drierite" or other desiccant is added, but for airmail shipment (and pollen should always be shipped by air where long distances are involved) this is not necessary and does more harm than good.

Thus, the extraction of pollen usually is a simple matter. However, when you receive requests for pollen, you will find that the breeders aren't satisfied with a shipment of pollen at just any time--they want it by a certain date, in time for their pollinations. Often their season will be considerably advanced compared to yours. This means early forcing which, in many species, becomes a real problem because, generally, the earlier material is taken in for forcing the longer will the forcing take and the more chances will there be for the flowers to dry out before pollen is shed.

Early forcing necessitates careful handling of the cut branches. The basal ends of the branches must be kept clean by frequent pruning, and the water should be replaced after each pruning. Possibly early development can be induced through some of the chemical treatments used by the flower growers, but to my knowledge, none has been used as yet by the tree breeders. Last year, however, we did some experiments with eastern hemlock in Connecticut trying to speed up development of cut branches with artificial illumination. We found that pollen would shed as much as 10 days earlier from cut branches exposed to a 20-hour light period than from those exposed to the normal daylength of 12 to 13 hours.

This method may be helpful in other species also. It is simple, and only a very low intensity of light is required. We used a 25-watt bulb connected to a time clock, but continuous illumination night and day probably would give almost as good results as the 20-hour daylength.

Another way to overcome the difference in time of pollen shedding between two localities is to store pollen from one year to the next. Pollens, however, vary in their ability to withstand storage. Some are so short-lived that it is doubtful whether we can ever store them for a whole year; others can be stored for long periods without difficulty. Pine and eastern hemlock pollens, for example, can be stored at 50 percent relative humidity and about 40° F. for at least a year with little loss of viability. High temperatures and low relative humidities both are detrimental to stored pollen.

When stored pollen is used, its viability must be determined prior to pollination. The germination of some pollen is easily tested by suspending it in a liquid medium, placing droplets of the suspension on a microscope slide in a moist chamber, and incubating it at relatively high temperatures. For pine pollen, a germination temperature of 79° F. has been recommended; chestnut pollen germinates at temperatures between 82° and 99° F.; and hemlock pollen gives good results at room temperatures. The media used range from simple ones, such as distilled water or sugar solutions in concentrations of from 1 to 20 percent, to complex nutrient solutions. For each kind of pollen to be tested, the optimum combination of conditions must be determined through experimentation. When that has been accomplished, one still is faced with the problem of interpreting the results obtained *in vitro* in terms of pollen behavior *in vivo*. Thus, pollen storage and testing of viability may be rather complicated, and attention should be given to the development of better forcing techniques.

To summarize, let me say this: As time goes by, the forester in the field will be called upon more and more frequently by geneticists for help with seed and pollen collection. Let us remain friends. The geneticists should limit their requests for material and information to what is essential, and the foresters should accept their fate and attempt to fulfill reasonable requests in spite of all the inconvenience it may entail.

## TRANSFER OF PLANT PATHOGENS AND INSECT PESTS IN SEED AND POLLEN

Keith R. Shea[1/]

Contaminated plant parts often serve to transmit disease incitants, their vectors, and other insect pests across state and national boundaries. Many important forest tree diseases and insect pests already have been introduced into the United States on infected or infested plant parts. Tragic examples include chestnut blight, white pine blister rust, the Dutch elm disease, and one of its vectors, the European elm bark beetle. Since many foreign pathogens and insect pests attack forest tree genera which also grow in this country, concern has been expressed over seed and pollen as a medium for their introduction.

Recently forest tree improvement has received increasing attention. Certain dangers, however, accompany such programs. Progeny trials use seed from distant sources. Controlled pollinations between native and exotic trees necessitate the shipment of pollen over great distances. Modern transportation methods not only insure seed and pollen viability, but, unfortunately, at the same time, protect accompanying contaminants.

1/ Assistant Professor, Department of Plant Pathology, University of Wisconsin, Madison 6, Wisconsin.

At present we know of few pathogens or insect pests of forest trees which are seed- or pollen-borne. However, it is reported that bacteriosis of walnut, leaf blotch of horse chestnut, chestnut blight, and an elm mosaic can be transmitted by the nuts or seeds. A leaf blight of cedar may have been introduced into the British Isles through seed from America. Many other illustrations can be cited which involve field and vegetable crops. Bacterial canker of tomato, bean anthracnose, oat smut, and common mosaic, a virus disease of bean, are a few examples of other seed-borne diseases.

The movement of seed from many plants is regulated by various state and federal quarantines. In some states, including Wisconsin, all seeds are covered in the definition of nursery stock and come under plant quarantine regulations which require inspection. In other states only certain seeds are included. Federal regulations prohibit the entry of many foreign forest trees or permit their entry under postentry quarantine. By and large, forest tree seed can be imported by permit. A notable exception is the seed from elm and all other plants of the family Ulmaceae from European sources which are prohibited entry into the United States. This quarantine was adopted in relation to the Dutch elm disease.

So far, pollen has not come under quarantine acts. At present it is impossible to estimate the risk involved in shipping pollen. It would appear, however, that the inclusion of floral or other plant parts would constitute a hazard. At the University of Wisconsin we have observed the larvae of unidentified insects in unscreened poplar pollen which had been stored for several weeks.

In lieu of definite quarantine regulations, the responsibility for introducing plant pathogens and insect pests in seed and pollen must rest with both the shipper and the receiver. Seeds and pollen should be thoroughly examined and all extraneous matter removed. Any material which is questionable should be destroyed. We in forest tree improvement should be constantly alert to the possibility of introducing new pathogens and insect pests.

## DISCUSSION--PANEL ON PROBLEMS OF SEED AND POLLEN COLLECTION, STORAGE, AND EXCHANGE

At the close of this panel there was vigorous discussion which had to be terminated by the moderator to stay within time limits. The gist of the discussion follows:

It is not clear whether or not existing quarantine regulations cover pollen; at least pollen is not mentioned specifically in them. There is some indication that elm mosaic can be transmitted from tree to tree through elm pollen. There may, therefore, be danger of distributing other pests with pollen.

The traffic in pollen doubtless will increase, and so far no methods are known by which pollen can be decontaminated without seriously impairing

its viability. Some research is under way, however, on this problem. It behooves all those involved to use extreme care in shipping pollen. Every effort should be made to obtain it from pest-free trees.

The shipment of pollen and seed is somewhat of a calculated risk. So long as we use intelligence and ordinary precaution we probably are on the safe side. So far as possible, both pollen and seed should, therefore, be collected and handled by trained scientific personnel.

It was suggested that trained pathologists and entomologists, as well as native plant material, should be sent to Europe and other foreign countries to determine (1) the insects and diseases which might be potential threats to our species, and (2) the reaction of these species to the diseases and insects now present in these foreign countries. It was agreed, however, that there is not much chance of preventing the shipment or transfer of unknown entities and that considerable difficulties will remain even after we know exactly what diseases and what insects we wish to prevent from entering our country.

## INTRODUCTION TO PANEL DISCUSSION ON VEGETATIVE PROPAGATION PROBLEMS

R. G. Hitt[1/]

Vegetative propagation and its associated problems are of paramount importance to the proper development of any tree improvement program. The establishment of adequate breeding collections, certain types of test plots, seed orchards, etc., are all dependent upon satisfactory manipulation of green thumbs, scions, season, and wax. Undoubtedly there is no one method that will fit all situations. Each research center, each research worker has to develop those techniques or "hybrids" of techniques which will best suit the local needs. And that is just what is happening! Air-layering of slash pine in Florida yields excellent results while air-layering on red pine in Quebec and in Wisconsin have been "rootless." Bottle grafting of slash pine in Florida gave promising results but not so in Wisconsin with red pine. Bare root grafting shows favorable grafting response for the southern pines and white pine. These and many other examples clearly illustrate that local species, site, and weather conditions play an important role in the development of satisfactory vegetative propagation techniques.

To help us understand and appreciate some of these problems, Keith Dorman and Mark Holst will discuss briefly some of the vegetative propagation projects under way at their respective stations. Should time permit, I shall cover some of the work in progress here in Wisconsin.

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1/ Forester-in-Charge, Forest Genetics Research, University of Wisconsin, Madison, Wisconsin.

# VEGETATIVE PROPAGATION PROBLEMS IN THE SOUTH

Keith W. Dorman[1]

Research in vegetative propagation of southern pines is directed towards perfection of methods for multiplying selected stock for research or commercial use. It is desirable to have stock on its own roots where inherent resistance to root fungi is being investigated, but either grafted or rooted stock is suitable for seed orchards or breeding collections. To date, a goodly proportion of research effort has been expended on slash and loblolly pines, and less on shortleaf pine and other species, including white pine.

Research in vegetative propagation methods and field tests of new methods are currently under way in Georgia, Florida, Mississippi, Arkansas, Louisiana, and Texas. Very strong staffs are maintained at the state and federal research stations, and consequently new developments occur constantly. It is expected that most of the problems in vegetative propagation will be overcome in the not-too-distant future, and that research time now devoted to these projects will be focused on other phases of tree improvement.

At present, air-layering techniques used successfully by Mergen at Lake City, Florida, on slash pine are being widely tested on slash pine, as well as other species. Results are as yet inconclusive, but it is evident that considerable modification of the treatments may be necessary for some species.

Tests in methods of rooting cuttings are being made at many places, but results are not very promising. The largest volume of work has been done with slash pine, but successful rooting is neither as high as with air-layering nor is the type of root system as desirable.

Grafting has been developed to the stage where material is being produced for seed orchard planting on an impressive scale. The Georgia Forestry Commission, for example, grafted 2,500 plants last spring with approximately 65 percent success. Grafts in the terminal shoot and in the seedling stem are possible. Moisture control in the scion is maintained in field-grafted plants with plastic bag covers. Bottle grafts in the field are also possible. In the greenhouse and lathhouse, shade, high humidity, and mist are used to reduce transpiration losses.

Some of the problems facing the researchers at present are: how to control disease and insect pests in stocks and scions; how to adapt research techniques to large-scale production; how to increase the percent of takes; how to modify basic methods of plant propagation to the peculiarities of the various tree species; and how to clarify stock-scion relationships.

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1/ Forester, Southeastern Forest Experiment Station, Macon, Georgia. Forest Service, U. S. Department of Agriculture.

The long, warm summers of the South permit use of air-layering of wild trees and grafting to established seedlings in the field. However, because of the large volume of material to be propagated, it is desirable to have techniques that can be used in all seasons. Also, some of them at least should be economical and suitable to mass production.

In conclusion, I would say that much has been accomplished in developing vegetative propagation methods to meet the needs in tree improvement research. Many problems remain, but our current research effort is strong, and it should not be very long until the major ones will be solved.

## GREENHOUSE GRAFTING OF SPRUCES AND HARD PINES AT THE PETAWAWA FOREST EXPERIMENT STATION

M. J. Holst[1/]

### INTRODUCTION

Vegetative propagation has been used for many years by horticulturists for the multiplication of a great many varieties of fruit trees, shrubs, and ornamentals. It was not until 1936, however, that Dr. C. Syrach Larsen, in Denmark, outlined the use of vegetative propagation in tree breeding. Without the aid of various vegetative propagation techniques the tree breeders would have been forced to use the slow techniques of pure line breeding. Using vegetative propagation, however, it is now possible to (1) facilitate future breeding work by establishing in one place a collection of plus trees which would otherwise be widely scattered and often inaccessible; (2) duplicate any one plus tree in as many plants as required; and (3) under uniform conditions (of soil and climate) rate the plus trees for their relative qualities.

The two methods of vegetative propagation that are of main interest in tree breeding work are (1) propagation by means of cuttings, and (2) propagation by means of grafting.

Frequently seedlings and saplings may be propagated by cuttings, but as soon as the trees reach the flowering stage the rooting of cuttings generally becomes poor. With the exception of some cottonwoods and willows, therefore, old trees usually must be propagated vegetatively by means of grafting. Selected plus trees of spruce and pine usually are mature or overmature. Mastery of the grafting techniques is, therefore, of primary importance in any tree breeding program.

1/ Research Forester, Petawawa Forest Experiment Station, Canada Department of Northern Affairs and National Resources, Chalk River, Ontario.

## ROOTSTOCKS

For successful grafting it is important to have fresh, healthy scions and good rootstocks. It is not always possible to secure healthy scions, but it should be possible to produce a sturdy and healthy rootstock of the desired size and shape.

### Choice of Rootstock Species

European experience has shown that most spruces can be grafted on Norway spruce (*Picea abies* (L.) Karst.) and that 2-needled pines should be grafted on 2-needled pines. Only a few experiments with interspecific grafting have been made at the Petawawa Forest Experiment Station, but some observations arise from them.

#### Spruce

Only Norway spruce and white spruce (*P. glauca* (Moench) Voss.) have been used as rootstocks, and the following species have been successfully grafted on both: Norway spruce, white spruce, red spruce (*P. rubens* Sarg.), Colorado blue spruce (*P. pungens* Engelm.), Serbian spruce (*P. omorika* (Pančić) Purkyne), oriental spruce (*P. orientalis* (L.) Link), Koyama spruce (*P. Kojamai* Shiras), dragon spruce (*P. asperata* Mast.), and various Sitka x white spruce hybrids. There have been no differences in take or development of these species attributable to the different species of rootstock employed. One attempt to graft black spruce (*P. mariana* (Mill.) B.X.P.) on Norway spruce failed, probably due to causes other than incompatibility between scion and rootstock.

In routine grafting, sometimes white spruce has proved a better rootstock and sometimes Norway spruce has done so, depending on the timing of grafting and subsequent handling of the grafted plants (see "Grafting Schedule").

#### Hard Pine

Scots pine (*Pinus sylvestris* L.) and red pine (*P. resinosa* Ait.) are used almost exclusively as rootstocks for hard pine grafting. On either species of rootstock the following species can be grafted satisfactorily: Scots pine, red pine, all varieties of *P. nigra* (Arnold) and Japanese red pine (*P. densiflora* Sieb. and Zucc.). It is likely that most pines of the group Lariciones may be grafted on these rootstocks.

A number of jack pine (*P. banksiana* Lamb.), lodgepole pine (*P. contorta* var. *latifolia* S. Wats.), and Virginia pine (*P. virginiana* Mill.), all of the group Insignes, have been grafted on Scots pine rootstocks with normal percent take. Growth of these grafts has not been entirely satisfactory, but it is as yet too early to judge whether Scots pine is a satisfactory rootstock for these species. If not, jack pine would be the preferred rootstock for these species in the group Insignes.

## SCIONS

Scions should be taken from the most suitable material, bearing in mind the requirements (which may vary with species) for a good scion, such as length, diameter, the preference for current year's growth, straightness, vigor, and, above all, the existence of at least one bud that will produce a vegetative shoot. Few living trees are so old that branches cannot be found which may be successfully propagated by careful grafting.

### Collection of Scions

Most of the scions collected for grafting are cut from branches of mature and overmature trees. The choice of suitable branches from such trees is limited, and great care must be taken with each tree to select the branches that will provide good scions. The scions should always be cut longer than the length to be used in order that the propagator may have some latitude when preparing them for grafting.

#### White Spruce

Usually it is impossible to find current shoots of sufficient length (3 to 5 inches) and quality to form a good scion in the top of a mature white spruce. The reasons are: (1) The weatherbeaten branch ends of old crowns have a short annual shoot growth and are usually much divided with short branchlets at every node. If the branches are thick enough, the propagator can usually cut suitable scions by trimming away small branchlets and grafting back on 3- to 6-year-old wood. However, such scions are regarded as poor material and will usually give a low take in grafting. (2) The branches in the upper part of the crown have often only one end bud, and if this bud happens to be a flower bud it may take many years before the grafted scion develops a vegetative bud. Grafts produced from such scions are useless as it is difficult to trim the rootstock in harmony with the weak scion.

On mature white spruces, the best scions usually can be cut from the lower, more shaded and protected parts of the crowns. By doing some searching, it is often possible to find branches with current shoots that, when cut back on 2- or 3-year-old wood, will provide a scion of reasonable quality.

However, the quality of scions collected from mature trees is generally low compared with those collected from thrifty middle-aged trees or from saplings. On middle-aged trees it usually is possible to find current shoots of sufficient length and thickness to form a good scion. Branches from the uppermost part of the crown are preferred because scions cut from them eventually give grafts of more upright and better form and give a better take (table 1) than do scions collected from the lower branches.

Table 1.--Percentage survival of grafts taken from the upper and lower part of the crown of open-grown, middle-aged trees

| Species | Survival when scions are collected from-- | |
|---|---|---|
| | Upper part of crown | Lower part of crown |
| Norway spruce | 82 | 75 |
| Red pine | 96 | 80 |

In practice, branch ends are cut much longer than the length of a scion. For mature trees, whole branch ends up to 18 inches long are collected and bundled, and later the scions are selected and trimmed by the propagator in the greenhouse shortly before grafting. For middle-aged trees, branch ends 2 to 3 times the length of the scion (about 10 to 12 inches) are collected.

Red Pine

Collection of scions from mature red pine presents only a small problem. Usually the current terminal shoots from the topmost branches of first order are long enough, but they are often too thick to make a perfect match with the rather small, potted rootstocks used in the greenhouse. The terminal shoots of second order are somewhat thinner and thus better suited for greenhouse grafting.

Suppressed branchlets with none or few side shoots, as are found in the lower part of the crown, can also be grafted, but not with as high a percentage take (table 1). These branchlets are grafted on 4- to 6-year-old wood and, therefore, require more care in grafting. The grafts produced with such scions will not grow as vigorously and will demand more skill in handling the first few years than grafts produced from the current year's shoots from the tops of the trees.

Flower buds are no obstacle in pine grafting. The male flowers are formed from the dwarf branch buds which otherwise would develop into needle fascicles, and the female flowers develop from the lateral buds below the terminal bud. In both, the terminal bud will produce a vegetative shoot which is what is required for the satisfactory development of the graft.

The scions should be cut 5 to 6 inches long, about 1/4 inch thick, and preferably from current year's growth.

### Jack Pine

Jack pine branches are rather thin. Usually the best scions can be cut from current year's growth of first order branches and preferably in the top of the tree. Suppressed branches in the lower part of the crown commonly are too thin and spindly to produce satisfactory scions.

## GRAFTING SCHEDULE

Rootstocks commence growth and reach the graftable stage according to the treatment they are given prior to grafting. This growth rhythm has to be taken into consideration when planning the grafting schedule and for the subsequent handling of the grafted plants. As the growth rhythm is different for spruce and pine, and can be modified considerably according to the time the rootstocks are taken into the greenhouse, the grafting schedule is quite flexible.

### Fall Grafting

It is the slight cambial activity of both rootstock and scion that makes it possible to graft in the fall. Ordinarily the temperature during this period is low, but favorable for callus formation which is the main evidence of growth activity. Neither rootstock nor scion starts shoot elongation. By the time growth is stopped by the winter frost, the grafts are sufficiently established to endure the winter. The mastery of the fall-grafting technique is an important contribution to a flexible grafting program, as scions can be collected in the fall when extensive seed collecting trips are made.

#### Spruce

Spruces have been grafted successfully in August, September, October, and November. As the grafts need a 6-week period to form sufficient callus to carry them through the winter, only the grafts made during August and September may be removed from the greenhouse and placed in cold frames in the middle of November. The grafts made during October and November must be overwintered in the greenhouse. Only Norway spruce rootstocks should be used for late fall grafting as there appears to be a pronounced difference in chilling requirements of the Norway and white spruce rootstocks. White spruces suffer considerably by being kept in the warm greenhouse over winter, and in the following summer show pronounced discoloration of foliage and reduced growth, while Norway spruces retain their healthy appearance.

Chilled fall grafts, besides being of better health, as mentioned above, have better survival than those kept in the greenhouse over winter (table 2). It also appears that early fall grafting is superior to late fall grafting regardless of whether the grafts are chilled or non-chilled.

Table 2.--Effects of chilling on spruce grafts

| Species | | Date grafted | Grafting success when material is-- | |
|---|---|---|---|---|
| Scion | Rootstock | | Chilled[1/] | Non-chilled[2/] |
| | | | Percent | Percent |
| Norway spruce | White spruce | Sept. 1 | 95 | 80 |
| White spruce | Norway spruce | Sept. 1 | 92 | 88 |
| White spruce | Norway spruce | Oct. 1 | 72 | 72 |

1/ Chilled grafts placed in cold frames November 15.
2/ Non-chilled grafts kept in the greenhouse over winter.

### Hard Pine

Fall grafting of hard pines has been limited to small lots of red pine scions gathered during seed collection trips in the first week of October and grafted a week later on Scots pine rootstocks. Half of these grafts were set out in cold frames on November 21, 1953, and the other half were retained in the greenhouse over winter. Forty-two percent of the chilled and 69 percent of the non-chilled grafts survived when counted in June 1954. It is apparently beneficial to overwinter such late fall red pine grafts in the warm greenhouse. It is as yet to be discovered whether early fall (August-September) grafting, with subsequent chilling, can be done with satisfactory survival.

## Winter Grafting

There are several methods of filling the greenhouse with rootstocks, and they are all important for the winter grafting schedule. The phenological behavior is quite different for rootstocks which have been placed in the greenhouse in early fall, late fall, and in the middle of the winter. By juggling the timing, it is possible to have graftable rootstocks in the greenhouse from the end of December to the start of the outdoor grafting season in May. However, it is usually desirable to have the winter grafting completed before March 15 in order to have time to prepare for the busy spring season.

### Spruce

Spruce rootstocks are most successfully grafted when the roots show abundant new growth or when the buds are swelling. Non-chilled white spruce rootstocks placed in the greenhouse during the fall suffer from lack of

chilling, as indicated by their unsatisfactory growth and discoloration, and are of doubtful value for winter grafting. Non-chilled Norway spruce rootstocks do not suffer so much from lack of chilling and are therefore better suited to be kept in the greenhouse over winter. In the spring, following grafting, the non-chilled white spruce start to turn yellow while similarly treated Norway spruces retain more of their lush green color. Norway spruce rootstocks give a higher survival than do white spruce.

### Hard Pine

Chilled red pine and Scots pine rootstocks should not be grafted too early. It is better to wait until the new growth is in the first stage of shoot elongation. The standard method for forcing red and Scots pine rootstocks is to place the rootstocks in the greenhouse in the early part of winter. After about 6 weeks in the greenhouse the rootstocks come into a stage suitable for grafting. Those taken in on January 15 will be ready about March 1.

It is probable that red pine and Scots pine could be kept in the greenhouse over winter and thus provide rootstocks for grafting from November to March inclusive. These non-chilled rootstocks have a lush, deep green color and almost continuous root and cambial activity. The commencement of shoot growth is much later than for the chilled rootstocks taken in in the middle of January, and the subsequent shoot elongation is somewhat retarded.

Such non-chilled rootstocks have been grafted in November and February-March with good success. On the few grafts made with chilled scions in February-March, it has been observed that the chilled scions grafted on non-chilled rootstocks have stronger shoot growth than similar scions grafted on chilled rootstocks. This has also been found in Dr. C. Heimburger's grafting experiments with white pine in Maple, Ontario.

## SCION STORAGE AND GRAFT PROTECTION IN THE SPRING GRAFTING OF RED PINE

M. J. Holst[1/]

Deep-freezing of coniferous scions prior to grafting was investigated in 1952 by the Forest Tree Breeding Institute at Ekebo, Sweden. It was found that deep-frozen scions were superior in health and percent take to scions held in cold storage.

Protection of the finished graft was attempted by the author when he worked with propagation of Scots pine in southern Sweden in the spring

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of 1950. At that time a few grafts were protected with a single glassine bag, but the grafts so protected died rather quickly due to excessive heat. Moist cotton placed in the glassine bag only delayed death a few days. Dr. C. C. Heimburger of the Ontario Department of Lands and Forests in Maple, Ontario, has rather successfully used for many years a double bag consisting of a glassine bag to retain moisture under a kraft paper bag to provide shade. The author has, since 1951, experimented on a small scale with the double bag, but instead of the glassine bag, whose water-retaining capacity is not very great, has used a polythene bag and added the kraft paper bag for shade. This double bag has been very satisfactory and was included in the experiment together with other protection devices.

The experiment was made up of two parts. The first part was an investigation of cold storage and deep-freeze storage for winter-cut red pine scions. The second part dealt with protecting and shading the finished graft, using two types of bags, a cardboard cylinder, and an unprotected control.

## MATERIALS

The scions were collected from mature trees at various points in Canada and the United States during the winter months (from January 15 to March 20). Some lots were almost a month in shipment, and certain of them were damaged either by "heating" or by excessive drying. It was necessary, therefore, to segregate the scions into two groups: (1) healthy, and (2) damaged in shipment.

The rootstocks used were 2-1 Scots pine planted in the spring of 1950.

## METHODS

### Storage of Scions

When the scions arrived at the Petawawa Forest Experiment Station they were stored outdoors until they were graded. During March the scions were cut into 5-inch lengths and three-quarters of their needles were removed. They were then dipped in a 1-percent Cemesan-M solution and each lot divided into two parts. One group, to be kept in cold storage, was packed in boxes with peat moss. The containers were placed in a seed storage room with ice packed around them. The temperature was planned to be just above freezing (33° to 35° F.). However, the freezing unit broke down and the temperature in the storage room rose at times to 45° F. Although there was ice around the boxes at all times, the high temperature made the scions wetter than was intended. The other group, to be held in deep-freeze, was packed in a mixture of snow and sawdust, wrapped in polythene film, and stored at a temperature of 0° F. in a freezing locker. The scions were placed directly in the locker without being quick-frozen and were removed from the locker in June. Only 2 days' supply was removed at a time and usually was left in a cellar for defrosting for 1 day before grafting. When grafted, the

deep-frozen scions had a fresh and crisp appearance, while the scions from the cold storage room were soggy, dull, and somewhat soft.

## Grafting

For greenhouse grafting, as well as for grafting out of doors, timing is one of the most important considerations in securing good survival. Our rule-of-thumb is to graft tolerant conifers (such as spruces, firs, and white pine) at the time of first root elongation, and out of doors, where the roots are less handy as indicators, at the time bud swelling begins. Intolerant conifers such as red, jack, and Scots pines should be grafted when the shoots of the rootstocks are elongating.

Our grafting was done from June 7 to 17, 1954. Leader elongation of the rootstocks was 4 to 5 inches, or about one-fourth of the total growth. The work was performed with a crew of 6 men: 2 men cleaned the rootstocks of needles and tied on the different protection devices, 3 men grafted, and 1 man waxed. Grafting was started at 5:00 a.m. The work was carried out in the early part of the day, as past experience has shown that grafting in the cooler forenoon, or in overcast weather, resulted in a higher survival than grafting in the hot afternoon. The summer of 1954 favored the survival of the grafts as the weather was abnormally cool, wet, and cloudy. The results might, therefore, not be quite typical for what can be expected in a more normal, dry and hot summer.

The grafting technique used was side grafting, also called veneer grafting. The scion was usually grafted on the leader formed in 1952. Occasionally this leader would be too thin for the quite thick red pine scion. In such cases scions were grafted on the 1951 leader. The scions were tied with raffia and waxed immediately. The current leaders were cut back to reduce diameter growth. If this were not done, callus formation would be vigorous and the scion might be "walled off." Reduced diameter growth also delays the strangling of both rootstock and scion by the raffia.

## Protection of Grafts

To test the possibility of increasing survival by protection of the graft, both cold storage and frozen scions were given the following protection: (1) poly bag plus kraft paper bag, (2) kraft paper bag only, (3) cardboard cylinder, and (4) no protection.

The poly bag was made up from a 6½-inch polythene tube. The tube was pulled down over the top of the rootstock and tied below the branch whorl under the graft. The tube was cut above the top of the rootstock and tied to seal in moisture. The poly bag thus made was then protected with a 25-pound kraft paper bag tied below the enclosed branch whorl. In this way three things were accomplished: (1) a mechanically strong bag, unable to slide off in high wind, was produced because it was "locked" below a branch whorl; (2) additional shade and moisture were secured inside the bag by including the branch whorl below the graft; and (3) the kraft

paper bag provided shade for the poly bag. This last feature seems quite important as previous experience has taught us that the most active tissue in an unshaded poly bag, i.e., the new growth and to some extent also the old growth of the rootstock, is killed ("cooked") by excessive heat and moisture. The scion, being more dormant, may not be killed in this unshaded poly bag, at least not within the first week. However, in this experiment we were interested in keeping alive the part of the rootstock above the graft. The kraft paper bag was, therefore, added to provide additional shade. When the poly bag plus kraft paper bag was removed 6 weeks after grafting, the new growth of the rootstocks displayed all colors from succulent green to withered brown. In the latter case it appeared that the old growth (from 1952) was sound and the cambium alive and active.

Protection with one kraft paper bag only was done with a 25-pound kraft paper bag which was tied below the branch whorl under the graft. Here, also, a branch whorl was included to give additional shade and moisture. Although shade was abundant and moisture probably somewhat increased, this bag was very hot, dry, and brittle in the bright noon sun. However, the new shoots of the rootstock were quite sound when the bag was removed 6 weeks after grafting.

The cardboard cylinders, 4 inches in diameter and 9 inches long, were made from old file covers. This cylinder was designed to shade only the graft and at the same time provide ample aeration to avoid excessive heat. The cylinder was slipped over the top of the rootstock and tied at the desired level. No extra branch whorl was included.

## RESULTS

A survival count made in the middle of October brought out several interesting features. At that time 73 successful grafts had been killed by the white pine weevil (Pissodes strobi). The weevil attacked and killed the Scots pine leader, sometimes above and sometimes below the grafted scion. The damage was fairly evenly distributed to all protection treatments. The grafts so killed were excluded from the summary.

Although total survival on July 17 was 74 percent, survival had dropped to 58 percent by October 15.

### Storage Methods

Deep-freeze storage is superior to cold storage for scions intended for outdoor grafting in the first part of June if scions are cut early in the winter when the trees are absolutely dormant and are subjected to no more than a short period of defrosting for preparation and grading prior to deep-freezing.

For the whole experiment, the deep-frozen scions survived 13 percent better than the cold-stored scions. Those scion lots which were damaged in shipment gave a take of 33 percent, which was only half that of the healthy scions (68 percent).

To analyze the results more closely, the different lots of scions were sorted out into three groups. The first group includes scions of good health, the second group includes poor scions damaged in shipment, and the third group includes healthy scions that were given cold-storage treatment only.

The influences of the cold-storage and deep-freeze treatments, and of the four protection methods, are most apparent for healthy scions. For these, the deep-frozen scions averaged an 80-percent take and the cold-stored scions 57 percent.

If the scions deteriorated during prolonged shipment, or were cut too late in the season, deep-freezing prior to grafting did not improve survival. The survival of such poor scions was generally low and the variation considerable; some lots suffered complete mortality. Over the whole experiment, survival of poor scions was 33 percent.

## Protection Methods

A poly bag plus kraft paper bag was the best method of protection. Compared with the control, the poly bag plus kraft paper bag gave an increase in percent take of 17 percent for good deep-frozen scions and 34 percent for comparable cold-storage scions. For poor cold-storage scions it nearly doubled the take from 22 percent to 42 percent, and for the healthy scions which were given the cold-storage treatment only, the increase was from 51 percent to 91 percent. Thus, the poly bag plus kraft paper bag gave a take of 89 percent for healthy deep-frozen scions, 74 percent for comparable cold-stored scions, and 91 percent for locally collected scions which were given the cold-storage treatment only.

Protection of the grafts with one kraft paper bag only was inferior to the poly bag plus kraft paper bag by about 6 percent. However, compared to the control, it gave an increase in percent take of 10 percent for good deep-frozen scions, 27 percent for good cold-stored scions, and 25 percent for scions which were given only the cold-storage treatment.

Protection of the grafts with a cardboard cylinder was only slightly beneficial. Compared to the control, it gave an increase of 6 percent for cold-storage scions (both good and poor), and only 3 percent for comparable deep-frozen scions.

Thus, the bag protection generally gave a higher take than the cardboard cylinder and the control. For all deep-frozen scions the bag protection was superior by approximately 10 percent, and for all cold-storage scions by approximately 25 percent.

Measurements made on June 28 gave an indication of the temperature differences at the grafts (table 1).

Table 1.--Temperature at the grafts with different kinds of protection, June 28, 1954

| Treatment | Temperature at grafts | |
|---|---|---|
| | Morning | Noon |
| | Degrees F. | Degrees F. |
| Poly bag plus kraft paper bag | 72 | 100 |
| Kraft paper bag only | 70 | 99 |
| Cardboard cylinder | 77 | 86 |
| Control | 76 | 86 |

It appeared that the two types of bag protection were cool in the morning owing to evaporating dew. At noon they were both quite hot, and while the poly bag retained the moisture and had a relative humidity of 100 percent at all times, the kraft paper bag was dry. Temperature appears to be a less critical factor than relative humidity in influencing the take of grafts. The take of the kraft paper bag protection may have been higher than that of the unprotected grafts because the relative humidity within the bag was higher than that of the atmosphere for the greater part of the day. The bag not only provided shade but also prevented rapid dissipation of the moisture from the enclosed transpiring branches.

Growth pattern as related to protection treatments was somewhat obscure but one point was brought out quite clearly: the scions protected with a cardboard cylinder grew the most. The cardboard cylinder apparently creates a favorable climate for shoot elongation but not for callus formation.

## NEW VEGETATIVE PROPAGATION METHODS FOR ASPEN AND WHITE PINE

C. Heimburger[1/]

During this spring and summer we have tried out two new methods of vegetative propagation that look promising enough to be reported to this meeting.

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1/ Forest Geneticist, Southern Research Station, Ontario Department of Lands and Forests, Maple, Ontario, Canada. This paper was presented by M. J. Holst in the absence of Dr. Heimburger.

## ASPEN

Aspen does not root from stem cuttings; propagation by means of root cuttings is rather circumstantial in a nursery where a great number of different aspen and poplar materials are being raised. Not all aspens lend themselves well to this method, i.e., they do not regenerate well from root cuttings planted vertically in the fall in the nursery, which is the only practical method for us. During several years we have tried to propagate aspens by means of bench-grafting of dormant scions onto dormant rooted cuttings of silver poplar (Populus alba) and willow (Salix purpurea and S. viminalis), but with very variable success. The method used was whip-and-tongue grafting. The grafts were put in boxes with moist moss at room temperature to produce callus and then kept at slightly above freezing where they remained relatively dormant until they were set out in the nursery in the spring. Many grafts produced according to this method rotted instead of forming callus, and thus far we have had only fair success with this method.

This year we tried plate budding (Jones budding) in our bench-grafting of aspens. The grafting was done in February-March. Buds were taken from dormant scions kept in snow in a deep freeze at about 25° F. or collected outside while still dormant. The rootstocks were rooted cuttings (0-1) dug up in the nursery, root-pruned, and with their tops removed to a stump of about 3 inches. They were stored in a box with moist moss in an unheated garage until used. The buds were removed from the scions as in ordinary shield budding, but instead of a T-shaped cut in the bark of the stock, a downward cut in the rootstock was made, through the bark and slightly into the wood. The cut was about 1¼ inches long. About one-half of the upper bark flap was removed and the bud was inserted behind the remaining bark flap. The lower part of the bud shield should fit snugly into the crotch formed by the bark flap and the stem. The top of the bud shield was tied with an ordinary rubber band (stationery rubber band No. 32) and a blob of grafting wax was placed over it. (See Kerr, W. L. 1937. Early spring budding by the plate method. Sci. Agr. 17(12): 713-719.)

The grafts were then allowed to callus in moist moss at room temperature, kept at slightly above freezing until planting time in the spring, and set out in the nursery. They were planted deeply, with the grafted bud just at the surface of the ground. The graft was made on the basal portion of last year's shoot from a rooted cutting.

The results obtained thus far are very encouraging. We have obtained about 80- to 90-percent take in most aspens. The buds sprout right through the blob of wax and the rubber bands rot away during the summer, requiring a minimum of care.

I have been told by several prominent plant propagators that bench-grafts should be put into a root cellar in barely moist coarse sand to form callus, and should be left there until planting time in the spring. We have no root cellar, but we do have access to ample refrigeration at

slightly above freezing. To those unfortunate people who work with aspens and have no root cellar, this method of grafting is highly recommended. Even if we had a root cellar with plenty of barely moist coarse sand, we would probably be inclined to stick to Jones budding with our aspen bench-grafts after the results obtained this year. If this method can be used with reasonable success in bench-grafting onto dormant <u>un</u>rooted cuttings of poplar and willow, there is reason to believe that a cheap method of vegetative mass propagation of aspens can be developed out of it.

## WHITE PINE

At the Third Southern Conference on Forest Tree Improvement held in New Orleans early in January of this year, Mr. H. C. Grigsby of the Mississippi Forestry Commission reported the following:

> "A new type of grafting, a variation of the bare-root method used with ornamentals, showed considerable promise last year and will be tried again this spring. Seedlings used for grafting stock are placed in sand (heeled in) in a greenhouse and the humidity is kept high. A side graft is made after root action begins. When union takes place, the stock plant is pruned back in the conventional manner. It is then potted and moved to a lathhouse. The advantage in using this method of grafting is that it saves the costly greenhouse space that is consumed by pots. About 30 grafts per square foot can be made when this method is used."

(See Proceedings of this Conference, p. 116. The materials grafted were southern pines.)

Bouvarel (Bouvarel, P. 1954. L'Amélioration des arbres forestiers en Suède et au Danemark, Annales de l'Ecole Nationale des Eaux et Forêts et de la Station de Recherches et Expériences 14(1): 40) states that bench-grafting onto stock with bare roots is being practiced in France with spruce, Douglas-fir, true firs (<u>Abies</u>), and Austrian pine. The stock is dormant at the time of grafting, and the author believes this to be one cause of rather heavy losses among the grafts during the winter following the grafting. The Mississippi method obviates this by grafting when root action begins.

This year we tried a modification of this method with white pine. At the time of lifting, in April, we selected some good, straight, and vigorous 2-2 white pine at one of our Provincial forest nurseries. The plants were trimmed a little at their base and heeled-in in a cold-frame with moist sand. The cold-frame was covered with sash and an unbleached cotton shade, and the plants were kept moist and warm until new root growth began. They were then lifted and bench-grafted with scions from selected blister rust resistant 12-year-old seedlings of resistant parents. Side grafting low on the stem was used and the grafts were tied with No. 32

stationery rubber bands. The roots were kept between moist burlap during transportation. The grafts were set out into inoculation beds and planted so that the place of grafting was partly below the soil surface. The inoculation beds are ordinary 4-foot-wide nursery beds surrounded by an 8-inch frame of lumber. The beds were covered with a lath screen and wet burlap and kept moist with a plastic hose sprinkler. All new growth on the stocks was removed shortly afterwards. As the grafts started new growth, the shades were gradually removed, but frequent watering was necessary during this very dry and hot summer. About 4 months later an average of 82 percent of the grafts were successful (table 1).

Table 1.--Success of bare root grafting of eastern white pine transplants

| Clone | Plants grafted early May | Plants surviving late August | Clone | Plants grafted early May | Plants surviving late August |
|---|---|---|---|---|---|
| | Number | Percent | | Number | Percent |
| 449 | 20 | 5 | 497 | 20 | 100 |
| 450 | 20 | 65 | 501 | 20 | 70 |
| 451 | 20 | 45 | 502 | 20 | 95 |
| 452 | 20 | 85 | 505 | 19 | 100 |
| 453 | 20 | 100 | 509 | 20 | 100 |
| 455 | 20 | 10 | 510 | 20 | 90 |
| 457 | 20 | 80 | 511 | 20 | 95 |
| 458 | 20 | 80 | 514 | 20 | 100 |
| 460 | 20 | 80 | 515 | 20 | 90 |
| 462 | 20 | 100 | 517 | 20 | 100 |
| 464 | 20 | 100 | 518 | 20 | 90 |
| 465 | 20 | 95 | 520 | 20 | 85 |
| 467 | 20 | 65 | 523 | 20 | 55 |
| 472 | 20 | 85 | 524 | 20 | 95 |
| 473 | 20 | 90 | 526 | 20 | 75 |
| 475 | 20 | 100 | 534 | 20 | 60 |
| 485 | 20 | 100 | 540 | 20 | 100 |
| 493 | 20 | 85 | 544 | 20 | 90 |
| 494 | 20 | 80 | 546 | 20 | 100 |
| 495 | 20 | 40 | All | 779 | 82 |

Possibly some of the clones showing poor take and survival are poor grafters. The rubber bands on the grafts have now largely rotted away. The grafting took about half the time of ordinary pot grafting and the grafts are ready for inoculation during next fall without much further care. They have produced about 4 inches of new growth, and all the tops of the stocks have recently been removed. The growth is bushy and compact and much better suited for inoculation than the somewhat leggy pot grafts. Of

disadvantage is the time of grafting when pressure for other work is very high. The scions were of the best possible quality, collected from young trees. Poorer scions will probably still require pot grafting. The method shows promise for mass propagation of white pine in conjunction with testing for resistance to blister rust.

## COMMENTS ON VEGETATIVE PROPAGATION RESEARCH CONDUCTED IN THE GENETICS DEPARTMENT AT THE UNIVERSITY OF WISCONSIN

R. G. Hitt1/

Investigations relative to the development of satisfactory techniques for vegetative propagation of selected breeding material have been in progress in the Genetics Department at the University of Wisconsin for several years. Unfortunately, until the winter of 1954-55 local greenhouse facilities were not available, necessitating the use of greenhouse facilities quite distant from the Madison offices. This procedure did not lend itself to close observation of the material with the result that detailed experiments and the attending necessary observations could not be made. Trials which were undertaken have been of real value, however, in helping to discover techniques which could be used in the tree improvement work here in Wisconsin.

### VEGETATIVE PROPAGATION BY MEANS OF CUTTINGS

Earlier work by a number of investigators has shown that this type of vegetative propagation is possible but quite unpredictable. Results in Wisconsin on white pine have shown a great range in percent of cuttings to strike root even though cuttings from the same trees were used in the trials in consecutive years. Trials with red pine have, generally speaking, given poor results. Trials established in late August with freshly gathered material yielded little or no rooting response for any and all treatments. The best response often was observed on the untreated controls. Basal heat was noted to stimulate callus and some root formation. Cuttings from 4-year-old trees gathered in early February were treated and "planted" in the greenhouse in a 50-50 mixture of sand and vermiculite. Again very little rooting was observed. One-half of the cuttings were stored in moist sphagnum moss for a period of 6 weeks before "planting." There was evidence of good callus formation on this material. However, in spite of this callus, there was no increased response in rooting. A high proportion of the cuttings had basal rot. Faulty mechanism in the watering system at times permitted the beds to become saturated, which may account for some of the poor results.

Outdoor cutting trials, started in the second week of May in northern Wisconsin with young cuttings (from 4-year-old trees), have shown promise.

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Readings made during the following fall indicate that there was a definite rooting response to 1 or 2 of the treatments. Further trials are anticipated.

## VEGETATIVE PROPAGATION BY GRAFTING

Greenhouse grafting of various hard pines has been in progress since the winter of 1949-50. The results have been poor with the percent of take running from zero to about 40 percent for some scion lots. Various understocks have been used, including red pine, jack pine, Japanese red and black pines, mugho pine, white pine, Scotch pine, and a few Austrian pine. Varying results have been obtained, and for some of the species sufficient numbers of the understock were not available to yield results of statistical significance. Increased daylength has also been attempted by means of artificial illumination with no appreciable increase in grafting "take" response being noted. For the past two field seasons, field grafting in the early spring has been attempted. The results have been encouraging. Of material grafted in the spring of 1954 onto transplant stock of red pine, 74 percent was still alive after 15 months. Incidentally, the scions used in this trial were shipped into Wisconsin from the Maritime provinces of Canada and, according to earlier trials, should have given us our poorest results because of delayed handling in shipment, etc.

The grafting done in the field during the spring of 1955, at this time, is from 8 to 65 percent successful. Various treatments were applied, including dipping the scions in a 25-percent solution of liquid latex prior to grafting, enclosing the graft and understock top in a polyethylene bag and enclosing this in a brown kraft bag. This procedure was followed until the early spring forced abandonment of bagging, after which we used liquid latex dipped scions exclusively. Although it is too early to determine definitely, the response of the scions that had a latex dip only was not too much different from those which had the polyethylene and kraft bags. Should further tests verify this observation, the use of latex dipped scions with no bagging would greatly accelerate the grafting work. The side or veneer graft was used exclusively during the past grafting season.

## VEGETATIVE PROPAGATION BY MEANS OF AIR-LAYERING

Air-layering trials have been undertaken on red, jack, white, and Scotch pines. The trials during the summer of 1954 were applied too late in the season although a few rooted branches were observed. On most of the branches treated, the girdled band was not large enough, with the result that a callus bridge was observed to have been formed across the girdled area. Wind and precipitation caused treated white pine branch tips to break off at the point of application. Readings which were made during early September on the 1955 trials for survival of the branch tips showed 46 to 92 percent still alive even after the rather hot, dry summer which followed application of the treatments.

## SUMMARY

Cutting trials to date have given poor results for red pine although a definite rooting response has been observed during the 1955 season. Basal heat is beneficial in increasing callus and root formation. The percent of successful greenhouse grafts has been increasing gradually over the years. However, field grafting results have been most encouraging, with the percentage of success being nearly double that of greenhouse grafts. The possible use of air-layering as a vegetative propagation tool in the Lake States is being investigated. Research on all phases of the vegetative propagation problem is continuing.

## DISCUSSION--PANEL ON VEGETATIVE PROPAGATION PROBLEMS

The effects of environment and local conditions on the effectiveness and success of various vegetative propagation methods were emphasized. Techniques for particular areas and particular species under a certain set of environmental conditions must be developed for each area. Ground temperature, air temperature, and relative humidity appeared as important factors in rooting. Very good results in the rooting and grafting of horticultural plants have been obtained under very high greenhouse temperatures of 110° to 115° when a continuous spray was provided. In Canada, there was little difference in grafting success with relative humidities ranging from 70 to 100 percent in the grafting chamber, but success was determined largely by the condition of the material, including both rootstock and scions.

In Canada, grafting rather than rooting of cuttings has been employed because of the selection and propagation of old trees. There they propagate all year round with the exception of 2 summer months. In many cases growth of red pine scions on Scotch pine rootstocks was better than red pine on red pine. Hence, it appears that Scotch pine can perhaps be used as a standard rootstock. A search is being made for such a standard rootstock for use in propagating spruce.

## NOTES ON STATISTICAL METHODOLOGY IN FOREST TREE IMPROVEMENT WORK

S. R. Gevorkiantz[1/]

Geneticists generally look upon tree growth as an interaction of genes under particular environmental conditions. The chief purpose of their tree-improvement work is to select or produce strains which are not only

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resistant to frost, drought, disease, and insect attacks, but which also give the highest return of good-quality wood per unit of area.

In order to be able to separate genetic effects from those attributable to environment, or to make best use of inherent qualities under a particular set of conditions, the tree-improvement men must know not only the genetic principles involved, but also the basic requirements of research methodology, including proper sampling, efficient experimental designs, and valid interpretation of data.

## IMPLICATIONS OF SCIENTIFIC RESEARCH AND EXPERIMENTAL DESIGNS

The initial stage of every research undertaking involves four basic considerations:

1. Precise definition and formulation of the problem.

2. Avoidance of bias.

3. Consideration of comparable conditions in the study of desired effects.

4. Selection of proper criteria and employment of efficient sampling and experimental designs.

A clear-cut statement of objectives will not only clarify the aim of the study but will also help to narrow down the research effort to some definite or specific channels. There is a common tendency among research workers to spread the effort too thinly over a large area instead of concentrating it at some specific points. The delimitation of the problem is also helpful in avoiding possible confusion in gathering and interpreting data.

Bias can be both intentional and unintentional. It may enter from many sources and under different names regardless of the bona fide attitude of research workers. It may occur as a result of poor planning or from the failure to recognize some important interactions in numerous cause-and-effect relationships. It may also come as an unforeseen change in the environment. Every effort should be made to minimize these types of bias at the planning stage of an experiment. Experience, competence, and imagination play an important role in obtaining more uniform and efficient data.

Experiments are often regarded as a study of variation. The observed variance is a reflection of many causes, and is the sum total of the variances produced by several independent factors. If this is so, then obviously one who studies the effects attributable to one cause should try to equalize whenever possible the effects of other contributing factors. Consequently, any effort to classify environmental conditions into separate categories will not only help to achieve uniformity but also will be very helpful in both the interpretation and application of the observed results.

Modern statistical methodology abounds in various types of experimental designs. In planning an experiment, the investigator should try to select an experimental design that fits the requirements of the problem, gives a valid estimate of the experimental error, and provides most accurate results per dollar spent. Also, proper criteria and the type of measurements needed should be decided upon at the start.

Scientific methods recognize only valid estimates since evidence is the only basis for inference. The validity of the experimental evidence depends on how much attention was given at the start to the three basic R's of statistical methodology, namely: randomization, representation, and replication.

Randomization, by which independence and equality of chances in selection are observed, serves a threefold purpose: (1) to minimize any bias in selection, (2) to provide a basis for our inference guided by the laws of chance, and (3) to guard against distortion of statistical errors.

Every sample should be representative. Even if the population is not homogeneous, it can be stratified and each stratum sampled or represented proportionally.

Replication of tests on different locations is also extremely important. Like randomization, it also serves a threefold purpose: (1) to reduce the sampling error, (2) to study the effects under conditions differing from each other, and (3) to guard against the failure of the entire experiment if a complete set of plots all established in one place is lost. Such heavy losses through fire or other causes do occur more frequently than we realize.

Some experiments are designed to test merely "what happens" under certain sets of conditions. Other experiments aim to provide additional information on "why" things happen the way they do. Frequently we fail to design experiments in such a way as to get more data at very little additional cost.

A large number of efficient experimental designs have been gradually developed during the last 30 years because of the nature and the variety of problems confronting research workers in different fields of science. One hears of randomized blocks, Latin squares, split-plot designs, factorial designs, balanced lattices, balanced and partially balanced incomplete blocks, and several other modifications of experimental layouts. Most of the basic and common designs are now well described in standard textbooks on the subject. In the time allotted to me, I can only touch upon some of the underlying assumptions employed in these designs.

All designs assume the same general thesis that the treatment and the environmental effects are additive and that the residual or unexplained effects, considered as the experimental errors, are independent from observation to observation. It is further assumed that the experimental errors follow the pattern of normal distribution and that the error

variance is constant over all observations. The analysis of variance, basic to all methods, consists of breaking down the sum of squares of the observed values into 4 component parts, 1 attributable to the general mean, 1 to differences between treatment or variety effects, 1 to differences in environmental effects associated with location, and 1 to residual effects, or experimental error.

All designs stress the importance of randomization and the reduction of the experimental error by increasing the number of replications, refinement of experimental techniques, uniform application of the treatments, and control of external influences. In short, they aim to eliminate bias and to provide comparability of the results.

Although different designs may employ different groupings or arrangement of experimental units, they all aim at elimination of simultaneous variation from a number of different sources. This is basic to all research.

All designs provide an unbiased setup to judge the significance of the observed results. Although the "true differences" between the various effects can never be evaluated with absolute certainty, the techniques employed in all correct designs enable the research workers to test their hypotheses with the assurance that the risk of erroneously accepting or rejecting them is, at least, very small. This, too, is basic to all research.

## TREE GROWTH AND HEREDITY

Forest growth is correlated with a large number of factors. It is governed by heredity, environment, and competition for space and nutrients. Any measure of growth must be studied, therefore, in relation to several independent or associated factors. Ideally, in every growth study, care must be exercised to keep all other factors except the one which is being investigated as constant as possible. As a rule, the factors to be equalized should be those which are considered to be influential but not correlated with each other. In this way, a series of individual comparisons of well-matched groups can be made on a rather simple basis. However, this experimental approach is not always possible. When individual comparisons cannot be paired without too much sacrifice in the amount of data, or when some of the factors are correlated with each other, thus producing joint effects, a regression technique becomes very useful.

Multiple regression equations are frequently used to estimate tree growth by reference to the values of other associated factors. With several factors affecting growth, it is imperative to know the relative importance of each. With the aid of multiple and partial correlation methods, a combined effect of a series of related factors is determined and the effect of any one factor is evaluated by holding the influence of other causative factors constant. When the relationship between two characters independent of the accompanying variation due to the other variables can be determined, the growth analysis becomes quite meaningful. By means of this approach, men engaged in forest tree improvement work can tackle

many problems: Is growth related to genotypes and to what degree? How successfully can the effects of environment and competition be evaluated and isolated from the genetic effects? Can an elite tree be recognized in a forest stand?

The partial correlation analysis consists of computing estimating equations where the effect of each factor is expressed in relative weights, and calculating all possible partial-regression coefficients and their significance as influential factors. If, for example, observations seem to indicate that geographic latitude and weight of seed are correlated with growth, the method of partial correlation analysis will not only bring out the association of growth with latitude but will also evaluate this association independent of the accompanying variation due to weight of seed. If the length of day varying with latitude forms genotypes differing in the rate of growth, this can be demonstrated by the correlation analysis. Furthermore, the effect of latitude can be studied under a variety of environmental conditions as well as the interrelationship between them.

The partial correlation analysis need not be considered as an entirely independent approach. Any properly designed experiment will yield both efficient and sufficient data for most correlation studies. Frequently, however, the regression approach is used on data obtained by sampling widely separated areas.

In correlation studies involving growth, the choice of independent factors affecting it is very important. This implies familiarity with the subject and a careful approach in providing comparable results. By way of illustration, I shall take the problem of selection of elite trees.

In the attempt to use exceptionally high growth as a criterion for selecting superior trees, the chief problem is to separate the environmental effects from those considered attributable largely to inheritance. Exceptionally good growth, for example, may be nothing more than the result of a combination of external conditions favorable to tree growth. On the other hand, if, under similar conditions of site, age, and competition, one encounters unusually high growth, it is justifiable to assume that some effectual hereditary qualities are involved.

The problem of separating environmental effects from those attributable to heredity is not a simple one because growth or tree size portrays an interaction of both intrinsic and external causes. Site index, for example, so commonly used in forestry to express the growth potential cannot be employed to separate soil and other site effects because tree height can be greatly affected by heredity alone. Thus, if site and heredity effects are confounded, it appears that the proper solution must lie in the equalization of site conditions rather than in the elimination of site effects on the basis of height growth itself.

The effects of crown competition or any lack of it, however, can be evaluated more successfully. The space allotted per tree controls its crown

development and consequently its rate of growth. By assuming, for example, that one-sixth of total height is the radius of an ample cylindrical space for tree development (with height equal to the length of crown) and estimating the proportion of this space unoccupied by other competing crowns, one can obtain a measure of relative freedom. Similarly, by dividing the tree basal area by the average basal area of the surrounding trees whose crowns occupy wholly or partly the allotted space, one can obtain a measure of the severity of competition which is exerted upon the tree. The volume production can then be related to these controlling factors. Here it is not the tree diameter and height which are used for evaluating the rapidity of growth but rather the causative conditions, such as availability of space or the degree of competition to which growth is so strongly related. Any unusual tree development, after allowing for space and competition effects, can then be regarded as very likely related to the superior origin of seed, particularly when allowance is made not only for site but also for the influence of other factors, such as age.

In the selection of superior trees, the approach can be reduced to the following scheme:

1. A hypothesis is made that plus trees, aside from being of good form, are those which exhibit exceptionally good development under similar conditions of site, age, and available space.

2. All effort should be made to see that other surrounding trees have developed under similar conditions of site as characterized by soil aeration, topography, climate, aspect, position on the slope, and water regime. This strict emphasis on uniformity delimits the selection of plus trees to rather small or restricted areas which are comparable in site conditions.

3. In addition to watching for comparable edaphic conditions, one should guard against other interfering factors. It is better, for example, to disregard trees which show signs of prolonged past suppression or sudden release from competition.

4. After the similarity of site conditions has been ascertained and non-comparable trees eliminated from consideration, the remaining trees, including possible plus trees, are scrutinized as to their growth performance in relation to their age and the degree of competition under which they have developed. By considering the ample space for crown development to be denoted by a cylinder whose radius is one-sixth of the total height and whose height is equal to the length of crown, and estimating the proportion of this space unoccupied by crowns of neighboring competitors, one would obtain a measure of freedom for development. By dividing the basal area of the tree under scrutiny by the average basal area of trees overlapping the cylindrical space, one would obtain a measure of the degree of competition involved. All these factors portraying the available space and the

degree of competition can be combined into one expression which may be called space-competition index. Such an index would provide a measure of an independent causative condition.

5. Now it will become possible to correlate volume or growth of trees with age and space-competition index, using the well-known techniques of partial correlation analysis. If such studies are made on the basis of many spot tests, convenient tables or graphs can be constructed which will aid others in depicting trees of certain species which show unusual development under the same conditions governing growth in a given space.

## CONCLUSIONS

I have briefly outlined some of the statistical phases involved in the relatively new field of tree improvement work. My chief purpose was to show that when the joint effects of hereditary and environmental factors are interlaced, extreme caution should be used in attempting to distinguish one from the other.

Whatever approach is taken, the problem can be solved only by the use of proper statistical methods. There are many good designs and techniques already available for almost any type of experimentation. Coupled with the knowledge of genetic principles and the peculiar characteristics of the tree species involved, these statistical designs and techniques will contribute a great deal to the acquisition of fundamental knowledge on the road which lies ahead.

# INTRODUCTION TO PANEL DISCUSSION ON TESTING FOR RESISTANCE TO DISEASE AND INSECTS

R. F. Patton[1/]

With the great rush recently of getting onto the forest tree improvement bandwagon, we hear much about the need for and the rosy promises of breeding for resistance to diseases and insects. Certainly the achievements along this line in other fields of agriculture give us every reason to believe that somewhat similar results may be obtained with forest trees.

In any program of breeding for resistance, a number of problems arise. Much emphasis has been placed upon selection for resistance and the necessity for inclusion of a wide variety of genotypes. Other problems, perhaps just as important, have been somewhat overshadowed by this quite valid concern with selection. It is our purpose here this morning to face some of these problems which arise from still another facet of a breeding program. Let us consider together some of the aspects of testing for resistance to disease and insects.

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# THE NATURE OF RESISTANCE TO INSECTS

Samuel A. Graham[1/]

Resistance of trees to insects may be broadly divided into two general categories: (1) resistance to attack, and (2) resistance to injury. Resistance to either attack or injury may be either genetic or environmental, and sometimes it may be difficult to determine which of the two is chiefly responsible for producing an observed condition of resistance. For example, resistance to attack by Dendroctonus beetles on ponderosa pine seems to be a function of age and vigor, and trees may be grouped into classes, as formulated by Keen, that will have different degrees of susceptibility to attack. Almost surely the vigor classes are a reflection of both site conditions and the inherited qualities that permit certain individual trees to utilize the site more efficiently than others. Thus, in testing the resistance of trees to the attack of beetles, all of the complex of factors that are combined in site must be equalized in some way.

Sometimes resistance is the result of observable characteristics of individual trees that are not greatly influenced by site conditions. To illustrate, resistance to injury by Dendroctonus beetles is the result of the ability of individual trees to produce a heavy flow of resin at points of beetle attack. Such trees are capable of "pitching out" the beetles.

Since the ability to produce resin is apparently related to the number of resin ducts present in the outer annual ring, the relative ability of the trees in a series to overcome beetle attack might easily be determined by direct examination of the wood.

Similarly, individual hard pine trees exhibit the ability to overcome the attack of the reproduction weevil, an insect that feeds on the phloem of young pines in the West Coast states. The resistance is the result of a copious flow of resin. In this instance, a tremendous increase in the number of resin ducts occurs in the wood laid down during the season of attack. A hybrid of Jeffrey and Coulter pines produced at Placerville is especially resistant to this insect, but individual trees of the various species of hard pines also show resistance, thus affording opportunities for selection.

Pines resistant to injury by the reproduction weevil also possess another physiological characteristic that is useful in overcoming an attack; that is the ability to surround and wall off areas of phloem which are injured with cork cells.

If similar characteristics were sought we might find individual pines that would be relatively resistant to the white pine weevil and other insects that attack the phloem of resinous species.

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Visible characteristics other than those mentioned may cause trees to be more or less resistant to certain insects. For example, aspens vary considerably in the character of the bark surface, and insects show a distinct preference for certain types of bark. The poplar borer prefers very smooth bark, and individual clones with relatively rough bark at an early age appear to be almost immune from the attack of this serious enemy of aspen.

In almost every insect infestation, individual trees exhibit more or less resistance. Little attention has been given to the detailed study of such trees to determine the causes of resistance. It seems likely that such studies would disclose some discernible characteristics that could be used to distinguish resistant trees.

Very often, however, resistant trees show no easily distinguishable differences from the susceptible individuals. For example, spruce trees resistant to the spruce gall aphid thus far have shown no recognizable difference from their susceptible neighbors. Possibly the resistant individuals have in their tissue some chemical substance repellent or toxic to the insects or lack some attracting substance.

Reportedly, the nun moth in Europe refuses to feed upon certain individual trees in the forest, but when branches from these trees are kept in water for a time they lose their repellent quality. Presumably some volatile substance, perhaps an oleoresin, is responsible for this.

Too little is known about the causes of resistance and some most promising opportunities for research lie in this field.

## EPIDEMIOLOGY IN RELATION TO TESTING FOR RESISTANCE TO DISEASES AND INSECTS

R. F. Patton[1/]

Testing for resistance to diseases or insects makes indispensable a familiarity with the disease or insect under consideration. The manipulation of test plant and pathogenic organism in order to provide a useful rating or index of relative resistance or susceptibility is the aim of testing. As a reminder of some points to be considered in the testing operation, let's look at a page or two from a plant pathologist's notebook.

### HEALTH AND DISEASE

In any program concerned with testing for resistance to disease (or insects), it is important to have a clear understanding of the nature of health and disease. Health, which might be defined as soundness of body

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and vigor of normal activities, is dependent not merely on freedom from disease but primarily on physiological stability. Disease is the inhibition or other disturbance of one or more of the physiological activities of an organism. It is not a static "condition."

The occurrence, course, and severity of disease may be influenced by numerous factors other than the mere presence and contact of suscept and pathogen. The study of these various factors influencing disease development is the concern of epidemiology.

## VARIATION IN THE NORMAL DISEASE CYCLE

Plant disease levels are variable. We recognize, for example, the existence of endemic and epidemic diseases, a classification based primarily upon the level or amount of the disease in an area. An endemic disease represents a low level of pest incidence, usually present in a given area under normal conditions. If it suddenly flares into prominence, a plant disease is described as epidemic.

Similarly, there is variation in the course of disease in an individual suscept or, perhaps, group of suscepts. A disease may be severe in one plant, whereas in another the disturbance of physiological processes may be hardly noticeable. Moreover, it is possible that both of these "levels" of disease represent the "normal" course of events, depending upon the influence of all the various factors affecting disease development.

Thus, the range of variation to be expected in any normal disease cycle must be known in order to differentiate the normal suscept reaction from the reaction of a resistant suscept. And, too, just as there is a range of variation in normal disease development and normal suscept reactions to disease, so also are there often different degrees of resistance to disease. Therefore, an accurate knowledge of disease development is essential to the recognition of resistance when it does appear in the trees being tested.

## THE SIGNIFICANCE OF PREDISPOSITION IN DISEASE DEVELOPMENT

We usually assume that activity of the "pathogen" is the direct cause of disease. However, we must not overlook the influence to varying degrees of numerous other factors in the development of disease. The activity of a pathogenic organism is only one factor and may be, in fact, only a relatively minor, if indispensable, one in disease development. The pathogens of many endemic diseases are always present, and other factors (e.g., age and vigor of suscept, weather, microclimate, etc.) actually determine whether disease development will occur. Heart rot of forest trees is such a case in point.

In working with disease resistance, then, we have developed the concept that disease resistance must be defined not alone in terms of organism-suscept relations, but also in terms that include the environmental conditions as they influence both suscept and pathogen.

## THE PATHOLOGICAL SEQUENCE

A pathological sequence includes the series of successive stages in disease development produced in the intimate relation between a pathogenic organism and an individual suscept. After initial dispersal of the inoculum, there are generally three successive series of activities: (1) inoculation--the arrival of inoculum at the infection court; (2) incubation--the revival of activity of the inoculum at an infection court, entrance into the suscept, and initiation of disease; and (3) infection--the subsequent activities of the pathogen which cause progressive disease in the suscept and development of a characteristic symptom picture.

The course of this sequence is influenced at all of these various stages by numerous factors other than the mere presence and contact of suscept and pathogen. These factors may be internal (heritable) or external (environmental), and may influence disease development through effects on the suscept or pathogen or both.

## FACTORS INFLUENCING DISEASE DEVELOPMENT

### Internal (Heritable) Factors

Susceptibility and resistance to specific diseases in plants are inherited just as are characters of morphology. So also is virulence heritable in pathogenic organisms. Individuals or strains of the suscept may vary widely in relative susceptibility, and strains of the pathogen may also vary considerably in virulence. Both functional and structural factors affect the occurrence, course, and severity of disease.

Factors affecting resistance of the suscept include such things as structure of protective organs and tissues, "pitching-over" of wounds, self-pruning tendency of suscept, seasonal maturation of tissues, presence of substances toxic to the pathogen, and ability to block progress of the pathogen by the formation of gums, resins, or wound meristems.

Factors affecting the virulence of the pathogen may include such things as longevity of spores, period of spore release, abundance of inoculum reaching infection courts, ability to live saprophytically, the necessity for an alternate host for completion of the life cycle, and ability to penetrate normal and wound barriers of the suscept, to name only a few.

### External (Environmental) Factors

Health and vigor of the suscept are dependent upon factors of the site and other external factors. These may also affect the pathogen in all stages of disease development, including dispersal of inoculum, inoculation, incubation, and infection.

The resistance of the suscept is influenced by climatic (including factors of the microclimate) components such as precipitation, temperature, light, weather injuries; by edaphic factors, including soil structure,

fertility, moisture, pH, etc.; and by biotic agents, limited almost entirely to the effects of man and other animals on the suscept, primarily in the form of injury. The latter are most important in providing infection courts, such as insect wounds or logging injuries.

Virulence of the pathogen may be affected at dispersal by such things as parasites and predators of the pathogen (affecting volume of inoculum), presence or absence of alternate hosts, and physical barriers. Inoculation may be affected by such things as winds and air currents, rainfall, running water, the presence of vectors, density and purity of stands of suscepts, and particularly temperature and humidity favorable to survival of inoculum. Incubation and infection are affected particularly by such factors as moisture, temperature and pH favorable to resumption and continuation of activity of the pathogen, and by the presence of antibiotic or antagonistic organisms in the substrate, especially in the soil. Factors of the microclimate play a very important role at this stage in many plant diseases.

## CONCLUSIONS

In testing plants for resistance to disease, we must strive to effect a maximum disease development in the plants under test. Therefore, it is important to be aware of the factors influencing disease development. It must be recognized, too, that there is a range of variation in normal disease development, as well as that susceptibility of the suscept and virulence of the pathogen are also variable.

A program of breeding for resistance calls for providing a broad base for selection by using the widest array of genotypes of the suscept. But it is just as important to provide as broad a base of exposure as is practicable in the testing phase. This stage includes not only encompassing the wide range of virulence exhibited by different strains of the pathogen, but also providing favorable conditions for disease development to insure a severe and uniform exposure. Here are included such steps as learning how to create a localized epidemic in the experimental field, the location of test plots at such places where the environmental factors are conducive to an epidemic outbreak, the manipulation of cultural conditions to increase disease exposure, and other similar measures.

# THE TECHNIQUES OF TESTING FOR INSECT AND DISEASE RESISTANCE IN FOREST TREES

Berch W. Henry[1]

I have been asked to introduce for discussion the topic of techniques of testing for resistance, and to do so in about a 5-minute period. Since

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my statement merely is to introduce the subject, I am relieved of any responsibility for covering all the phases involved and am reserving the right to express opinions which may or may not be substantiated by facts. It follows that my statement will leave much unsaid and possibly ample room for disagreement with what is said. That's where the "discussion" part of this panel discussion comes in.

Before we start testing we must know for what we are testing. In this case it is labeled "resistance." As a beginning, we might define resistance as that faculty which enables a plant to withstand repeated attacks of a given pest to the extent that the plant's usefulness to man remains unimpaired. You pathologists may recognize that as a facsimile in reverse of an often-used definition of a plant disease. But for most practical purposes that is what we are after.

Given a plant of unknown reaction to a certain malady, how then can we determine its resistance? In each individual case, we must <u>know</u> the disease or insect concerned. The more we know about its natural life history, the more intelligently can we approach the search for resistance. Too often our work on resistance is delayed by the necessity of learning more about the life history of the pest. Be that as it may, the plant to be tested must be exposed to the particular pest in an environment where known susceptible plants succumb to attack. In some cases Mother Nature does a pretty effective job for us in what we call natural inoculation or exposure; in others we give her an assist in what is called artificial inoculation by natural means; and, finally, in the category of strictly artificial inoculation, we apply the pest in unnatural means and amounts, often under conditions of environment that favor the pest over the host plant.

In the methods just mentioned there are inherent dangers which must be kept in mind. With natural inoculation, are we sure the pest-free individuals are not "<u>escapes</u>," and with the types of artificial inoculation, are we eliminating individuals that would <u>not</u> have succumbed to the pest in nature?

With each of our individual programs, these generalities, plus the consideration of many details peculiar to the specific situation will determine the techniques we employ. The details of design of test, numbers of individuals, replications, etc., should, of course, reflect the best we can do with the materials, facilities, and manpower available.

I have listed, more or less in chronological order, a few forest pests which have received varying degrees of attention in this country from the host resistance standpoint and the general techniques of testing that have been employed:

| Pests | Techniques of testing |
|---|---|
| Chestnut blight | Natural and artificial inoculation |
| White pine blister rust | Natural and artificial inoculation |
| Dutch elm disease | Artificial inoculation |
| Mimosa wilt | Artificial inoculation |
| Littleleaf disease of pine | Natural and artificial inoculation |
| Pine reproduction weevil | Natural and artificial inoculation |
| Fusiform rust of pine | Natural and artificial inoculation |

We could list many more. However, this group shows two pests for which artificial inoculation has been emphasized as a testing technique and five in which both natural and artificial inoculation have been used. I'll venture a guess that if exposure to the malady in nature had given a severe enough test in a reasonable period of time, artificial means would not have been used.

## TESTING FOR INSECT AND DISEASE RESISTANCE

R. D. Shenefelt[1/]

The topic assigned for this portion of the panel is "Odds and Ends." There are numerous additional factors which might be discussed with regard to testing for insect and disease resistance. Some are:

1. The techniques are not worked out in most cases. They will depend upon what is wanted in the future.

2. The variability of the pathogen, or insect, must be considered as well as that of the host. For example, the white pine weevil has been unusually abundant on red pine in Wisconsin during the last year or so. Is the weevil changing its habits? This means that the pest must be tested thoroughly to determine its capabilities.

3. Techniques of testing must allow for the possibility of indirect resistance through resistance to certain predisposing factors or to a vector.

4. The relation of resistance to other desired characteristics must be included.

5. The resistance of parent selections to that of progenies remains to be determined, i.e., the aspects of transmission.

6. How pure do we want the lines? How much uniformity are we seeking? What is a barrier for one animal or disease may well be a highway for

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another. The more uniform our forests become, the more subject they may be to attack. In selecting for resistance to one insect or disease, we are undoubtedly setting the "table" for another. How thorough should the testing be?

7. For what type of environment should resistant strains be developed? Do we want red pine for plantations, for future natural stock, or for both purposes?

8. One of the things needed by geneticists, pathologists, and entomologists is a cover type plan for the future to guide research and testing programs in order to attempt to solve problems before they become critical.

9. Care must be taken in setting out test plantations not to place them on soil treated with insecticides or fungicides. Many of the newer insecticides have a rather amazing persistency in soil and many of them also appear to influence root development, mycorrhizal organisms, etc.

10. For how long a period do we want the resistance, i.e., at what stage? Do we want white pine to be resistant to white pine weevil at all times, or are we most interested in its escaping injury through the seedling and sapling stages?

11. Techniques of testing must make provision for separating temporary and more permanent resistance. Many repeated and replicated tests will be required. The problem is illustrated by the fact that certain bur oaks were heavily fed upon by June beetles at the Griffith State Nursery during 2 or 3 successive years, while others, of the same size and appearance, were only lightly utilized. Then the picture changed.

12. Testing must be continued until the cause of resistance is determined. In some cases this will require detailed morphological examination, or possibly detailed chemical examination to answer the question. Why should white pine, jack pine, and Norway spruce be heavily attacked by the white pine weevil and white spruce and red pine ordinarily ignored? What are the differences responsible? Assuming that the differences are located and are of a chemical nature, then many things may be done, such as the testing of various strains of conifers for the particular constituents involved and the determination of the response of insects to the chemicals by means of olfactometers.

Most of the points brought out are questions. And this appears to show well our present position in the matter of testing of trees for insect and disease resistance. At the present time it is easy to speak in generalities but very difficult to become specific.

## BREEDING FOR HIGH-QUALITY WOOD

Harold L. Mitchell[1]

Engineers, chemists, architects, furniture designers, and other major users of forest products think of wood primarily as an engineering material that has a rather wide range of physical properties and comes in a variety of sizes, grades, colors, grain patterns, and textures. They will continue to use wood as a raw material only to the extent that it is readily available, reasonable in price, and better adapted to their particular product or use than metals, plastics, or some competing organic fiber. Their choice of materials is little influenced by sentiment, forestry tradition, watershed protection problems, recreational needs, or even by the striking beauty of a fine stand of tall, straight, clean-boled trees. The important pulp and paper industry, for example, probably would not hesitate in turning to bagasse, cattails, or even corn silk, if such materials proved cheaper or better adapted to their product than wood fiber.

Therefore, if we are realistic, we shall not overlook the requirements of the principal consumers of wood products in planning our forest genetics research program. I think one of our major objectives should be the development of trees that will produce more of the kinds of wood desired by the major users of forest products. In other words, we should give quality and end-use requirements a more prominent place in our thinking and planning. In some of the preceding papers and discussion, considerable emphasis was placed upon attaining exceptional growth rates. In this connection, I should like to point out that growth rate in itself is of questionable importance if the wood thus produced has little or no value in the market place. The Forest Survey figures show that in this country we are already growing an enormous volume of wood, principally hardwood species, that is largely unmerchantable. The deficit in our growth-drain balance is in high-quality material, for which there is a great present and potential demand.

### DEFINITION OF WOOD QUALITY

So far we have used the term "high-quality" in the sense usually employed by both foresters and laymen; that is, fast-growing, vigorous, pest-resistant trees with long, straight, clear boles, free of all visible defects. This concept of quality is all right as far as it goes. In the interest of breeding truly elite trees, however, it should be expanded to include the basic anatomical and physical properties that, in the final analysis, determine the suitability of wood for a given use, be it pulpwood, boards, structural timbers, poles, or veneer. Of particular importance are such properties as the density of the wood, the proportion of

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1/ Chief, Division of Timber Growth and Utilization Relations, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, maintained at Madison, Wisconsin, in cooperation with the University of Wisconsin. This paper was read by B. F. Kukachka in Mr. Mitchell's absence.

summerwood to springwood in the annual rings, the number of rings per inch, the length and thickness of the wood fibers, the orientation of the fibrils with respect to the axis of the fibers, and the occurrence of compression wood or other abnormalities that affect strength, shrinkage, warpage, or pulp quality and yields.

Wood density, usually expressed as pounds per cubic foot, or as specific gravity, is perhaps the simplest and most useful single index to wood quality from the standpoint of physical properties. To illustrate, every 2-pound increase in wood density of southern yellow pines produces about 1 pound more kraft pulp (fig. 1). Stated another way, a cord of low-density southern pine wood will yield about 847 pounds of kraft pulp, but a cord of high-density wood of the same species will produce 1,477 pounds--almost twice as much. The same general relationship between wood density and kraft yields is true of other species.

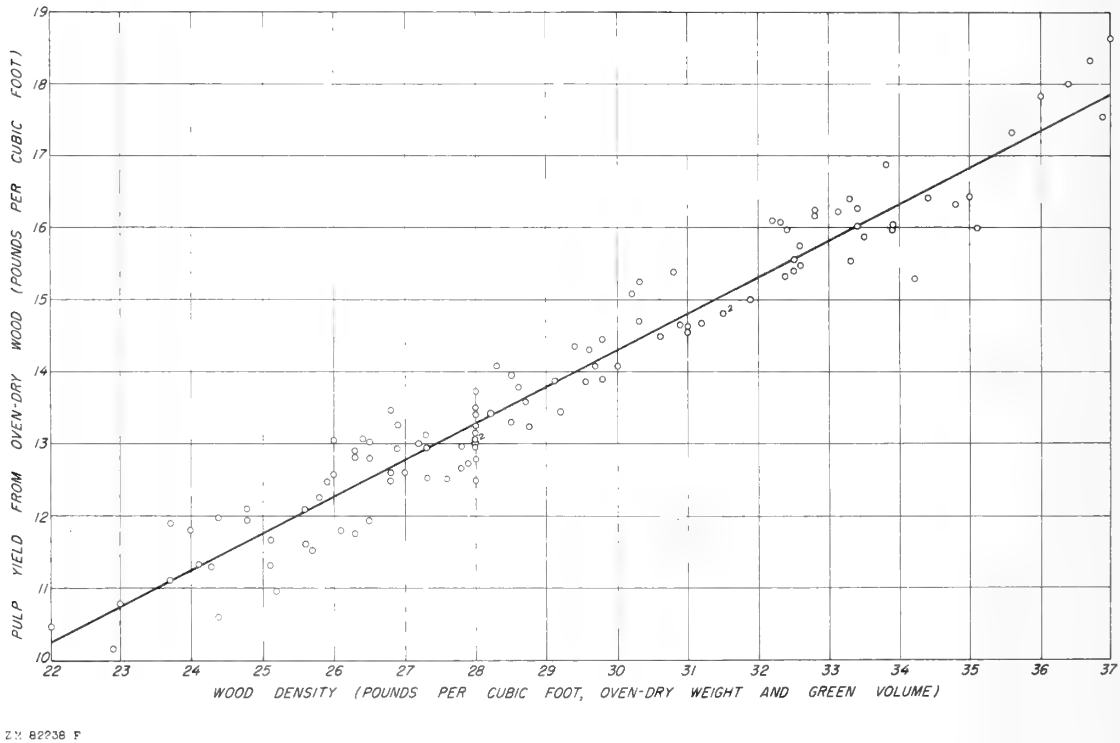


Figure 1.--Relationship between wood density and kraft pulp yields of southern yellow pine pulpwood.

In this paper I will draw heavily on southern pine data for illustrations, partly because more is known about southern pines than any of our other major species, and partly because research in forest genetics started earlier and is moving more rapidly in the South than in most other sections of the country.

There is a well-established relationship between specific gravity and mechanical strength, expressed as modulus of rupture (fig. 2). Specific gravity is, therefore, a primary factor in the segregation of structural-grade timbers that command premium prices in the lumber market, and also in the selection of material for high-grade piling, transmission poles, and other uses where strength is of major importance.

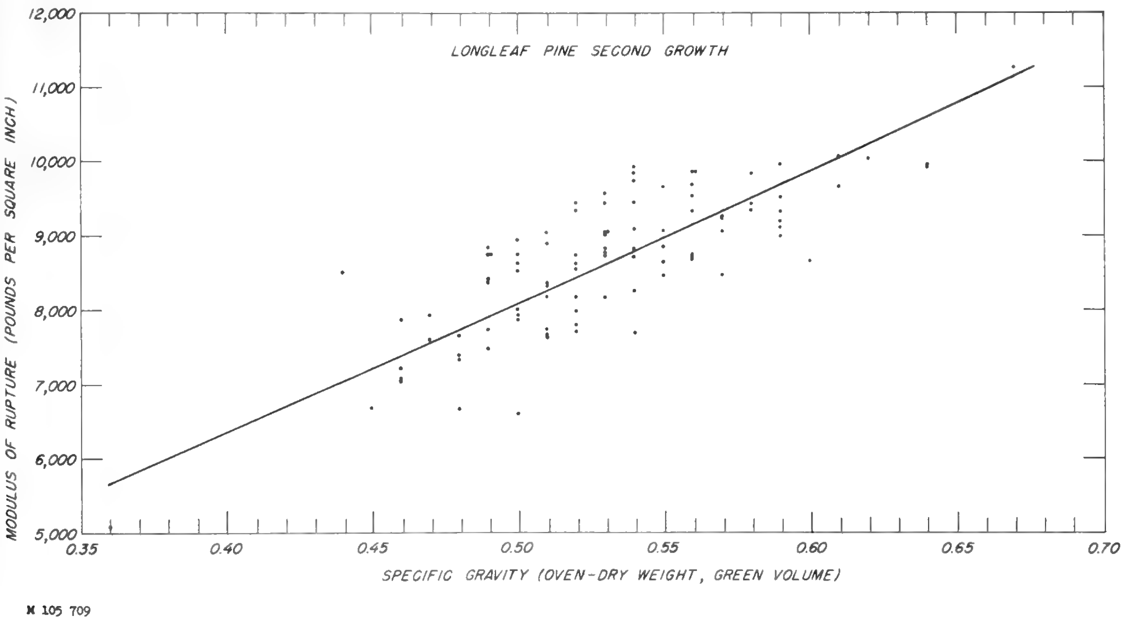


Figure 2.--Relationship between the specific gravity of longleaf pine wood and its modulus of rupture.

High-density wood also shrinks less along the grain than low-density wood. Accordingly, when high- and low-density wood occurs in the same board, differential shrinkage causes the board to warp upon drying. This condition, which may produce pronounced bow, twist, or crook, is common in southern pines grown under certain conditions, and to some extent in other conifers.

Another key feature is the proportion of summerwood to springwood in the annual growth ring. Springwood is the inner portion of the growth ring formed early in the growing season, and summerwood is the outer portion formed later in the year. Springwood is composed of relatively large-diameter, thin-walled cells, and summerwood of smaller, thicker walled cells. Springwood is lighter in weight, softer, and weaker, and shrinks more along the grain than summerwood. Thus, the greater the proportion of summerwood to springwood in the growth rings, the greater the strength of the wood and the pulp yield therefrom, and the less the longitudinal shrinkage.

The significance of another feature--fibril angle--looms larger as we learn more about it (2, 4). Fibrils, which are believed to be composed of strands of cellulose chains, make up the layers of the secondary wall of the wood fibers. Their orientation with respect to the long axis of the fibers is termed the fibril angle. Large fibril angles are the rule in compression wood, an abnormal wood (formed on the under side of leaning trees) that has extremely poor strength and shrinkage properties, and in normal wood of low density and low mechanical strength. Small fibril angles, in some cases practically parallel to axis of fibers, are typical of high-density, strong wood of low shrinkage along the grain.

I could give you additional examples of the importance to the forest genetics program of intrinsic wood quality--that is, the basic anatomical characteristics that determine the suitability of wood for lumber, pulp, or any other use. However, I believe I have presented sufficient evidence to convince you that volume growth and external indicators of quality are not in themselves adequate criteria to use in the selection and rating of plus or elite trees.

In this connection, I should like to call your attention to the fact that tree species vary about as much in anatomical features as in growth rate, vigor, branching habit, and other readily determined characteristics. An idea of the variation in specific gravity found in nature can be obtained from the frequency-distribution curves for four southern pines (fig. 3). Considerable variation in fibril angle and proportion of summerwood to springwood has also been found, even in pines of the same species and age growing on the same site.

Some of the observed variation in physical features is no doubt attributable to direct and indirect effects of environment. The remainder probably is due largely to inherent differences in the individual trees within a species or racial strain.

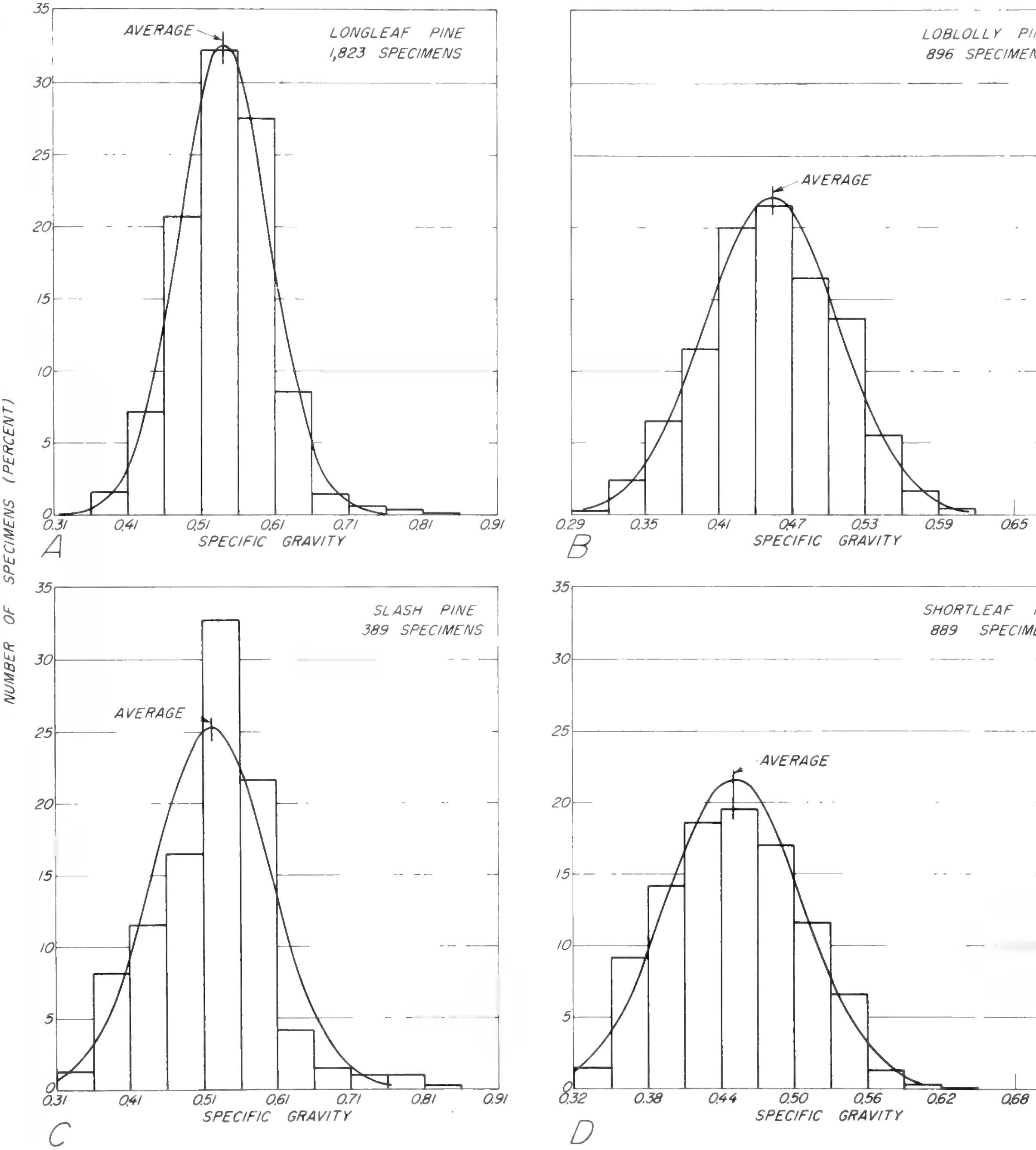


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Figure 3.--Frequency distribution of specific gravity values for four species of southern yellow pine.

## RATING PLUS TREES FOR INTRINSIC WOOD QUALITY

In the individual tree selections made to date, as in the majority of hybridization studies, emphasis has been placed upon such readily determined desirable characteristics as vigor, growth rate, form, branching habit, resistance to pests, drought resistance, and gum yields. This was a natural development because few of the organizations that pioneered forest genetics research in this country were staffed or equipped to make precise wood-quality evaluations. Another obstacle was lack of fast, accurate, non-destructive techniques for making such analyses. I wish to make it clear, however, that leaders in this field were fully aware of the importance of wood quality as here defined, and have repeatedly emphasized the need for such quality determinations.

It was to meet this need that the Forest Products Laboratory a year ago undertook to develop the kind of techniques needed to facilitate this phase of the forest tree improvement program. Most of the needed "tools" are now available. These new techniques permit rapid, accurate determinations on large numbers of small samples from living trees. One is Smith's (6) maximum moisture method for determining specific gravity of aggregate or single annual rings in increment cores and of exceedingly small samples of separated springwood and summerwood. Another, developed by Marts (3), involves the use of fluorescent microscopy for measuring fibril angles directly on cores from standard increment borings, thus eliminating the need for sectioning the material and mounting on slides.

We are now set up to make a considerable number of wood-quality evaluations of certain softwood species. We plan to concentrate on southern pines, for reasons previously stated. Next in order of priority will come Douglas-fir and ponderosa pine. For the present, we shall work mainly on the backlog of plus trees that have been selected by other field units of the U. S. Forest Service in connection with their tree improvement research, largely on the basis of growth rate, form, and other external indicators of quality. It is important that these otherwise potentially elite trees at least meet minimum wood-quality standards. Next, we shall work with the Forest Experiment Stations in seeking out individual trees that appear to be truly outstanding in anatomical features as well as external characteristics.

In our current work with these coniferous species, wood-quality evaluations are based largely on three anatomical and physical features; namely, percentage of summerwood, fibril angle, and wood density. As we have seen, all are strongly correlated with such quality factors as mechanical strength, shrinkage, pulp yields, and properties. Collectively, they should provide a reasonably reliable index to the suitability of wood for lumber, pulp, or other common uses.

Results of previous research--such as the well-established relationship between wood density and pulp yields--provide a standard of comparison or rating scale. Trees can thus be classified as below average, average, above average, or outstanding from the standpoint of intrinsic wood quality.

In setting up our working hypothesis we assumed that these anatomical and physical features, especially fibril angle and wood density, are subject to strong genetic control, as in the case of growth rate, gum yield, and the tendency to crook. There is considerable evidence to support this assumption. In any event, this study of selected plus trees, and later their progeny, together with related studies also in progress, should provide reliable data on the extent to which these anatomical and physical features are inherited in southern pines. This research should also contribute to present information on trends and range of variability of these features.

Other properties will, of course, have to be taken into consideration when we get to the rating of hardwoods that are used chiefly for furniture, cabinet work, and interior paneling. For such uses, machining properties and appearance will be about as important as strength, dimensional stability, and freedom from reaction wood or other abnormalities.

Let us consider figure, for example. "Bird's eye," curly grain, and other distinctive grain patterns are much sought after in fine cabinet woods, and command premium prices. There has been much speculation, but little experimental data, regarding the extent to which such grain patterns are inherited. In my opinion, this would be a fruitful field for research, especially here in the Lake States.

A promising lead in this connection was discovered more or less by accident in connection with some natural hybrid poplars located in Iowa about 2 years ago by the Ames Research Center of the Central States Forest Experiment Station and Iowa State College School of Forestry. Of particular interest are trees from a small stand which apparently originated as root suckers from an individual natural hybrid of good form and growth rate. Bolts from two of these trees were sent to the Laboratory for routine testing, especially for pulp yields. However, a few of the bolts were run through the new veneer slicer, largely to try the machine, and it was noted that the resulting veneer had a very attractive curly grain. Additional samples were then obtained from the stand, sliced into veneer, and all were found to have the same distinctive grain pattern.

If all the hybrid poplars in this particular stand originated from a single clone, as seems probable, then there is a chance that the distinctive grain pattern is subject to strong genetic control. Progeny tests are now under way to test this hypothesis.

## SIGNIFICANCE TO WOOD-USING INDUSTRIES

I have tried to give you an appreciation of the importance of intrinsic wood quality in forest genetics research, including a few examples of how present information is being put to practical use, and a brief summary of the status and objectives of current work in this field at the Forest Products Laboratory. Thus far I have stayed pretty close to factual data. Now I hope you will permit me to speculate a little and make some educated guesses as to what forest genetics may contribute to industry in the foreseeable future.

A simple example will serve to illustrate the economic potentialities of some of the tree improvement research already in progress. We know that a well-stocked, well-managed stand of run-of-the-woods southern pine growing on a good site will produce an average of 1 cord of pulpwood per acre per year over a 40- to 50-year rotation. We know, too, that there are found in nature individual southern pines capable of much more rapid growth--trees that produce merchantable pulpwood of a given size in a shorter period. At least part of their superiority is believed due to genetic factors, as in the case of hybrid poplars. Assume that we can increase the inherent growth rate of southern pine by one-half through selection and breeding of superior trees. The result would be an equivalent increase in kraft pulp yield per acre per year; that is, from 0.55 up to 0.84 ton per acre per year (fig. 4).

Now assume that we can develop a strain of southern pine inherently capable, under average conditions of growth rate, stocking, site, and management, of producing wood with a specific gravity of 0.68, only 0.23 higher than the present average of about 0.45 for run-of-the-woods, pulpwood-size trees of these species. If specific gravity is subject to genetic control, as seems probable, such an improvement in wood density should be readily attainable through selection and breeding. (We have already found southern pines with specific gravities ranging up to 0.75 and above.) The effect of such a modest (50 percent) increase in wood density upon kraft pulp yields is the same as an equivalent increase in growth rate (fig. 4). In other words, increasing the density of the wood by one-half has the same effect on fiber yields per acre per year as increasing the volume of wood by one-half. This further illustrates the importance of wood density, a factor so often overlooked in forest management as well as in genetics research.

If, through selection and breeding, we can achieve a 50-percent increase in both growth rate and specific gravity, kraft pulp yields per acre per year from southern pines would be increased by about 2.3 times (fig. 4), and fiber-production costs at the woods level would be substantially reduced. In monetary terms, assuming that a ton of kraft pulp is worth $90, such elite trees would yield enough fiber to make kraft pulp valued at $114.30, as compared to $49.50 worth of pulp per acre per year from run-of-the-woods trees. The financial advantage of the greater fiber yields would be sufficient to justify clear cutting existing natural stands when they are ready for harvest and then replanting with superior stock instead of managing the stand for natural restocking with seed of poorer parentage. I believe that Lake States species can be similarly improved.

Lumbermen, too, would be interested in this kind of elite tree from the standpoint of volume increment and because the higher specific gravity would substantially improve the strength and dimensional stability, and therefore the value, of lumber, structural timbers, and other products cut therefrom.

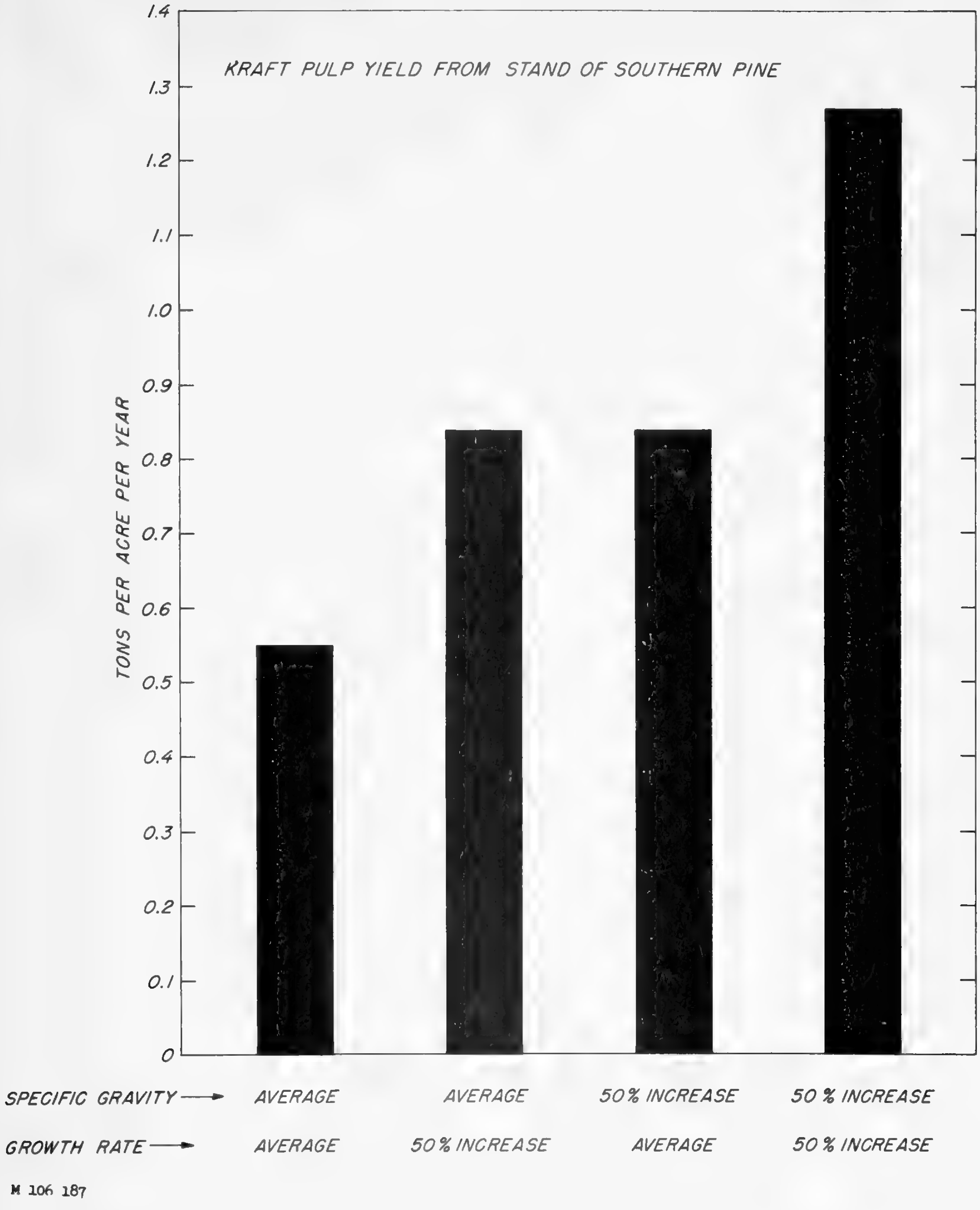


Figure 4.--The estimated effects of increases in specific gravity and growth rate on kraft pulp yields from southern pine.

Now let us consider the possibilities of selection and breeding to attain strictly qualitative objectives. Take the proportion of summerwood to springwood, for example. It is known that pulp sheets made experimentally of practically pure springwood felt better than those made of summerwood (1); also, that the bursting strength and tensile strength of paper tend to increase with increases in the proportion of springwood to summerwood. On the other hand, the stiffer summerwood fibers make rougher sheets of paper whose resistance to tearing increases with the proportion of summerwood to springwood.

As pointed out earlier, trees differ considerably in the proportion of summerwood to springwood produced in their annual rings. Selection and breeding might therefore develop new strains capable of producing either higher or lower proportions of these two component parts of the annual ring, depending upon the proportion best adapted to the requirements of the end product.

We know, too, that the occurrence of compression wood, and of normal wood with large fibril angles resembling those found in compression wood, tends to reduce pulp yields and bleachability, and has an adverse effect on important strength properties (5). Wide fibril angles are also typical of lumber of low strength, high longitudinal shrinkage, and a tendency to warp and twist. Fibril angles must therefore be given a prominent place in forest genetics research aimed at improving pulp- and lumber-producing softwoods. Then there is the important and largely unexplored field of breeding to modify the thickness, length, and other properties of wood fibers, and the adhesive characteristics of the lignin that cements them together. It might even be possible to reduce the amount of lignin. My own feeling is that genetics research directed at achieving such qualitative modifications may prove more beneficial to the wood-using industries than current studies that largely emphasize more limited quantitative objectives. With the great variety of species we have, and with the wide variations in anatomical and physical features we find within species, the opportunity for improvements along such lines is almost limitless. I believe we can eventually develop new hybrids that will yield wood fibers tailor-made to the requirements of a particular product or end use.

## THE ROLE OF INDUSTRY IN GENETICS RESEARCH

Industry has done an outstanding job of research and development in the processing of wood in the form provided by nature. Advances in paper chemistry and engineering, for example, have improved pulp-making efficiency to the point where, in some cases, processing costs now represent not more than 30 to 40 percent of the value of a ton of pulp. The lumber and plywood industries have made similar improvement in their processing equipment and techniques. But the basic raw material used by industry has remained the same, or declined in quality, and has greatly increased in price. Would it not be to industry's advantage to strengthen research aimed at making the production of their basic raw material as efficient as their processing methods? I am thinking especially of some

of the opportunities I have mentioned for improving the quality and lowering the cost of the raw material.

We sometimes forget that quality control starts in the woods--not in the pulpmill, sawmill, or plywood plant. We are dealing not with a mineral that is mined, but with organic fibers produced in living trees that, like all agricultural crops, can be modified and improved in both yield and quality through culture, selection, and breeding.

I am not suggesting that every major user of wood embark upon his own program of research on forest tree improvement. Neither do I wish to imply that industry now is doing nothing in this field. I know that some companies have modest programs of their own, that others are contributing funds and facilities to strengthen the genetics work of established public and private research agencies, and that the wood-using industries are ably represented on both national and regional forest tree improvement committees and advisory groups.

I sincerely believe, though, that industrial agencies' support of such research is nowhere near in line with either the current or long-term benefits they stand to gain. I think it would be definitely to their advantage to step up their own research in this field, and to increase their support of those established public and private agencies which are sufficiently well staffed, equipped, and experienced to conduct effective tree improvement research.

In conclusion, I should like to put in a plug for basic research of the kind that usually pays the largest dividends in the long pull. Too often such research is sidetracked by the inevitable pressures for quick results. However, real progress of the break-through type will not be possible until fundamental research provides new knowledge and basic principles on which to build. I sincerely hope that the Lake States Forest Tree Improvement Committee, and especially the industry representatives, will not neglect fundamental research along some of the lines I have suggested.

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## ACTIVITIES OF THE SUBCOMMITTEES OF THE LAKE STATES FOREST TREE IMPROVEMENT COMMITTEE

Paul O. Rudolf[1/]

The work of our Forest Tree Improvement Committee has been carried on primarily by the following four subcommittees: seed collection zones (F. J. Hodge, chairman), tree and stand selections (P. O. Rudolf, chairman), bibliography and directory (S. H. Spurr, chairman), and projects for study (T. Schantz-Hansen, chairman). Except for the latter, brief reports will be presented by the subcommittee chairmen.

The subcommittee on projects for study attempted to assemble a list of forest tree improvement projects needing study and to rate them on a scale of priority and costs or funds required. This proved to be a rather ambitious undertaking at this stage of development. Furthermore, several collegiate institutions have added forest genetics instruction and research to their programs since the subcommittee was formed, so it has been decided to reconstitute the subcommittee. The new group will have the benefit of the information already assembled and can take a new look at the situation. A formal report will, therefore, be deferred to a later meeting.

1/ Chairman, Lake States Forest Tree Improvement Committee.

# THE SUBCOMMITTEE ON SEED COLLECTION ZONES

F. J. Hodge[1/]

Our subcommittee was charged with developing seed collection zones for the Lake States upon the basis of some readily available climatic data. This we considered a first step toward forest tree seed certification for the region.

We examined seed collection zones developed by C. G. Bates and P. O. Rudolf for red pine and by H. L. Shirley for the Lake States region, and the U. S. Department of Agriculture tree seed collection policy. We consulted foresters and nurserymen in the three Lake States. We considered zones based on mean July temperatures. All previous or suggested zones seemed to have some unsatisfactory aspects

At the suggestion of T. Schantz-Hansen and Paul Rudolf, we then developed some zones based on the summation of temperatures above 50° F. Paul Rudolf checked the development of red pine of many seed sources against these zones and found rather good agreement. There appeared to be some need, however, for subdividing these "degree-day" zones from east to west. Average January temperatures seemed to provide a good basis for this division. Using intervals of 1,000 "degree-days" above 50° F. and of 4° F. in average January temperature provides some 26 zones in the Lake States. Disregarding those that occur to a very limited extent only, there are only 8 to 10 zones per state. For use strictly within a state, it probably would be sufficient to use only the degree-day zones. This would provide 6 for Minnesota, 5 for Michigan, and 4 for Wisconsin. A report describing these zones and embodying our recommendations has just been reviewed and approved by the subcommittee. After further review and suitable revision it will be published and distributed.

We have also been considering another phase of seed certification. At a meeting held earlier this year at East Lansing, Michigan, it was proposed that a uniform seed testing law be prepared for agricultural seeds, and a draft of such a law was prepared. It was also suggested that the proposed law be broadened to cover forest tree seeds as well. We are working on that possibility now. If this can be done, the way should be open for this model law to be adopted by a number of states. Whether or not such laws are adopted, our next step should be to work toward certification of forest tree seed not only as to origin but also as to quality.

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1/ Forester, Division of Forestry, Michigan Conservation Department, Lansing, Michigan. The other members of this subcommittee are B. L. Berklund, W. H. Brener, J. W. Macon, P. O. Rudolf, and T. Schantz-Hansen.

## THE SUBCOMMITTEE ON TREE AND STAND SELECTION

Paul O. Rudolf[1/]

The objective of this subcommittee is to assemble the best possible criteria for selecting superior forest trees and stands in the Lake States. Its aim has been to put this information in clear and simple language so that field men unacquainted with technical genetics terms can follow and use the descriptions.

A preliminary report was reviewed by the entire subcommittee. It was then revised and submitted to the entire Tree Improvement Committee and several well-qualified people outside the Committee. As a result of this review, the report was revised further and it is now believed to be in good shape.

The report lists and discusses briefly the important characters of forest trees which are known with reasonable certainty to be strongly controlled by heredity. These include growth rate, seed production, form, branching habit, resistance to enemies, wood quality, volume and quality of products other than wood, tolerance, and response to daylength. In addition to these characters which apply to all species, additional, more specific characters are described for most of the important forest tree species of the Lake States. Included are red pine, eastern white pine, jack pine, white spruce, black spruce, balsam fir, tamarack, eastern hemlock, sugar maple, red oak, and aspens. Mentioned also is the importance of selection of trees superior for windbreak and shelterbelt, erosion control, wildlife, and Christmas tree purposes.

The report suggests both methods and means of reporting superior trees and stands and proposes a method of procedure for utilizing the superior trees and stands in a forest tree improvement program.

The subcommittee report is ready for publication except for one bottleneck. The plan has been to use numerous photographs and drawings to illustrate and clarify the text. Several hundred photographs have been examined, but a number of the desired illustrations still are to be found. It was hoped to use line drawings for some of the illustrations, especially where photographs were lacking, but there has been difficulty in locating an artist who could do the job satisfactorily and at a reasonable fee. As soon as these difficulties are overcome--and I believe they soon shall--we expect to complete the report and have it published. It should serve a very useful purpose in our tree improvement program.

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1/ Forester, Lake States Forest Experiment Station, Forest Service, U. S. Department of Agriculture, maintained in cooperation with the University of Minnesota at St. Paul 1, Minnesota. Other members of this subcommittee are E. J. Adams, R. G. Hitt, H. E. Ochsner, P. W. Robbins, A. J. Riker, and S. H. Spurr.

## THE SUBCOMMITTEE ON BIBLIOGRAPHY

Stephen H. Spurr[1/]

It was the original purpose of this subcommittee (1) to compile a bibliography of forest genetics literature published by authors or agencies in the Lake States or, if originating elsewhere, pertaining to forest tree species growing in the Lake States, and (2) to prepare a directory of workers and agencies engaged in forest tree improvement work in this region. The latter objective was dropped in view of the activities of the SAF's tree improvement committee in this field.

A preliminary bibliography compiled by William J. Libby under the direction of the chairman and with the help of the other members of the subcommittee was distributed for review last October. Since then valuable additions and corrections have been received from Paul O. Rudolf but from no others. Unless further additions are received, the bibliography will be considered complete.

An index to the bibliography is now being prepared following the Oxford system of classification, used also in Forestry Abstracts. It is hoped to publish the final version of the bibliography within the coming year.

## REORGANIZATION OF THE LAKE STATES FOREST TREE IMPROVEMENT COMMITTEE

Paul O. Rudolf[2/]

When the Lake States Forest Tree Improvement Committee was formed in April 1953, it consisted of nine members representing the forest schools, the state conservation departments, forest industry, and the Lake States Forest Experiment Station. Its main purpose was stated as "to encourage and coordinate forest tree improvement work in the region." One of the important objectives of the Committee was to represent both the agencies and subject matter interests involved in forest tree improvement work.

As soon as the Committee began to function, it was apparent that several important subject matter interests and some vitally concerned agencies were not represented. Accordingly, each of the four subcommittees was enlarged by the addition of some members outside the Committee. In this manner the fields of genetics, forest entomology, and wood technology, and such agencies as the Institute of Paper Chemistry, the North Central

1/ Professor, School of Natural Resources, University of Michigan, Ann Arbor, Michigan. Other members of this subcommittee are B. H. Paul, P. W. Robbins, P. O. Rudolf, and T. Schantz-Hansen.

2/ Chairman, Lake States Forest Tree Improvement Committee.

Region of the U. S. Forest Service, and the Forest Products Laboratory, were brought into the work of the Committee.

Profiting by its own experience and that of similar groups in other regions, the Committee decided to reorganize as follows:

1. Membership is to be increased from 9 to 14, members to be nominated by the agencies they represent.

2. Members are to serve for 4 years with no restrictions on the number of terms a member may represent his agency.

3. To provide for overlapping terms, half of the members shall be appointed every 2 years.

4. Instead of a single chairman there shall be three officers: chairman, vice-chairman, and executive secretary. As a rule, the chairman shall be from the state in which the next regional conference is to be held. Tenure of office shall be 2 years for chairman and vice-chairman. As suggested by W. H. Brener and approved by the group, the executive secretary shall be a continuing officer and shall be the representative of the Lake States Forest Experiment Station on the Committee.

5. Regional conferences shall be held at 2-year intervals.

As a result of this action, membership of the Lake States Forest Tree Improvement Committee at the close of this conference shall be as follows:

SERVING UNTIL 1957

| Member | Agency represented |
|---|---|
| Earl J. Adams | Minnesota Conservation Department |
| B. L. Berklund | Lake States Council of Industrial Foresters |
| W. H. Brener | Wisconsin Conservation Department |
| R. A. Brink | University of Wisconsin |
| P. W. Robbins | Michigan State University |
| Paul O. Rudolf | Lake States Forest Experiment Station |
| S. H. Spurr | University of Michigan |

SERVING UNTIL 1959

| Member | Agency represented |
|---|---|
| F. J. Hodge | Michigan Conservation Department |
| A. C. Hodson | International Committee on Diseases and Insects |
| P. N. Joranson | Institute of Paper Chemistry |
| H. L. Mitchell | Forest Products Laboratory |
| H. E. Ochsner | North Central Region, U. S. Forest Service |
| S. S. Pauley | University of Minnesota |
| A. J. Riker | International Committee on Diseases and Insects |

A nominating committee consisting of F. J. Hodge, H. E. Ochsner, and S. S. Pauley selected the following candidates for office: Earl J. Adams, chairman; W. H. Brener, vice-chairman; and Paul O. Rudolf, executive secretary. (These officers were elected by unanimous ballot.)

Tentative plans are to hold the next meeting in Minnesota during 1957.

The conference was adjourned at 2:40 p.m.

## LIST OF THOSE REGISTERED AT THE CONFERENCE

Adams, Earl J., Minn. Conservation Dept., Div. of Forestry, St. Paul, Minn.
Ahlgren, Clifford E., Quetico-Superior Wilderness Research Center, Ely, Minn.
Ahlskog, Ralph, Region 9, U. S. Forest Service, Milwaukee, Wis.
Allworden, William, Nekoosa-Edwards Paper Co., Port Edwards, Wis.
Baer, John, Nekoosa-Edwards Paper Co., Port Edwards, Wis.
Baum, Martin, Marathon Corp., Rothschild, Wis.
Beale, John A., Wis. Conservation Dept., Madison, Wis.
Berklund, B. L., Nekoosa-Edwards Paper Co., Port Edwards, Wis.
Borkenhagen, Jack, Chequamegon National Forest, Park Falls, Wis.
Brener, W. H., Wis. Conservation Dept., Wisconsin Rapids, Wis.
Carlson, Ray, Wis. Conservation Dept., Wisconsin Rapids, Wis.
Clarke, Eric K., Kimberly-Clark of Minn., Inc., Duluth, Minn.
Cooper, T. G., Nekoosa-Edwards Paper Co., Port Edwards, Wis.
Dickerman, M. B., Lake States Forest Experiment Station, St. Paul, Minn.
Dorman, Keith W., Southeastern Forest Experiment Station, Dry Branch, Ga.
Dosen, Robert, Nekoosa-Edwards Paper Co., Port Edwards, Wis.
Drake, Charles R., Univ. of Wis., Dept. of Plant Pathology, Madison, Wis.
Eggen, C. T., U. S. Bureau of Indian Affairs, Minneapolis, Minn.
Einspahr, Dean W., Institute of Paper Chemistry, Appleton, Wis.
Esenther, Glenn, Univ. of Wis., Dept. of Entomology, Madison, Wis.
George, L. E., Kimberly-Clark Corp., Neenah, Wis.
Gevorkiantz, S. R., Lake States Forest Experiment Station, St. Paul, Minn.
Graham, S. A., Univ. of Mich., School of Natural Resources, Ann Arbor, Mich.
Granum, Bernard M., Iron Range Resources & Rehabilitation, Hibbing, Minn.
Hartig, Richard, Univ. of Wis., Dept. of Genetics, Madison, Wis.
Henry, B. W., Southern Institute of Forest Genetics, Gulfport, Miss.
Hitt, Robert G., Univ. of Wis., Dept. of Genetics, Madison, Wis.
Hodge, F. J., Mich. Conservation Dept., Lansing, Mich.
Holst, Mark, Petawawa Forest Experiment Station, Chalk River, Ontario
Houston, David R., Univ. of Wis., Dept. of Plant Pathology, Madison, Wis.
Hurd, E. S., Consolidated Water Power & Paper Co., Rhinelander, Wis.
Hyypio, Peter A., Institute of Paper Chemistry, Appleton, Wis.
Johnson, Albert G., Nashotah, Wis.
Joranson, Philip N., Institute of Paper Chemistry, Appleton, Wis.

Kapler, J. E., Univ. of Wis., Dept. of Entomology, Madison, Wis.
Kaufert, Frank H., Univ. of Minn., School of Forestry, St. Paul, Minn.
Koenings, R. H., Wis. Conservation Dept., Wisconsin Rapids, Wis.
Kukachka, B. F., Forest Products Laboratory, Madison, Wis.
Kuntz, James E., Univ. of Wis., Dept. of Plant Pathology, Madison, Wis.
Lewis, David K., Wis. Conservation Dept., Wisconsin Rapids, Wis.
Limstrom, G. A., Central States Forest Experiment Station, Columbus, Ohio
Macon, J. W., Consolidated Water Power & Paper Co., Rhinelander, Wis.
Marquis, Ralph W., Northeastern Forest Experiment Station, Upper Darby, Pa.
McComb, A. L., Iowa State College, Ames, Iowa
McCulley, R. D., Lake States Forest Experiment Station, St. Paul, Minn.
Moran, John J., Wisconsin Conservation Dept., Wisconsin Rapids, Wis.
Nienstaedt, Hans, Lake States Forest Experiment Station, St. Paul, Minn.
Nighswander, James E., Univ. of Wisconsin, Dept. of Plant Pathology, Madison, Wis.
Ochsner, Herbert, Region 9, U. S. Forest Service, Milwaukee, Wis.
Parmeter, John R., Lake States Forest Experiment Station, Madison, Wis.
Patton, Robert F., Univ. of Wis., Dept. of Plant Pathology, Madison, Wis.
Pauley, Scott S., Univ. of Minn., School of Forestry, St. Paul, Minn.
Petry, Robert A., Nekoosa-Edwards Paper Co., Port Edwards, Wis.
Place, I. C. M., Univ. of Wis., Dept. of Forestry & Wildlife Management, Madison, Wis.
Ralston, R. A., Lake States Forest Experiment Station, Wausau, Wis.
Rudolf, Paul O., Lake States Forest Experiment Station, St. Paul, Minn.
Samuelson, C. A., Kimberly-Clark of Mich., Inc., Marquette, Mich.
Sasaki, Toshio, Univ. of Wis., Dept. of Plant Pathology, Madison, Wis.
Schenk, John A., Univ. of Wis., Dept. of Entomology, Madison, Wis.
Shea, Keith R., Univ. of Wis., Dept. of Plant Pathology, Madison, Wis.
Shenefelt, Roy D., Univ. of Wis., Dept. of Entomology, Madison, Wis.
Spaeth, J. Nelson, Univ. of Ill., Dept. of Forestry, Urbana, Ill.
Sylvester, William A., Trees for Tomorrow, Inc., Merrill, Wis.
Thomas, Philip, Kimberly-Clark of Mich., Inc., Iron Mountain, Mich.
Torgerson, Kenneth G., Kimberly-Clark of Minn., Inc., Duluth, Minn.
Troemner, Allan, Wis. Conservation Dept., Wisconsin Rapids, Wis.
Underwood, Norbert B., Wis. Conservation Dept., Wisconsin Rapids, Wis.
Unger, James W., Wis. State College, Oshkosh, Wis.
Weber, Ray, Blister Rust Control, U. S. Forest Service, Antigo, Wis.
Welsh, S. W., Wis. Conservation Dept., Madison, Wis.
Wilson, F. G., Madison, Wis.
Zasada, Z. A., Lake States Forest Experiment Station, Grand Rapids, Minn.

## COMMON AND SCIENTIFIC NAMES OF TREE SPECIES MENTIONED IN THE TEXT

| Common name | Scientific name |
|---|---|
| Ash, white | Fraxinus americana |
| Aspen, bigtooth | Populus grandidentata |
| Aspen, European | P. tremula |
| Aspen, quaking | P. tremuloides |
| Birch, gray | Betula populifolia |
| Birch, paper | B. papyrifera |
| Birch, yellow | B. alleghaniensis |
| Caragana (Pea shrub) | Caragana spp. |
| Cherry, black | Prunus serotina |
| Cherry, mazzard (European sweet) | P. avium |
| Chestnut, Chinese | Castanea mollissima |
| Cottonwood, eastern | Populus deltoides |
| Cottonwood, black | P. trichocarpa |
| Douglas-fir | Pseudotsuga menziesii |
| Elm, American | Ulmus americana |
| Elm, Buisman | U. carpinifolia (clone) |
| Elm, Siberian | U. pumila |
| Fir, balsam | Abies balsamea |
| Fir, Fraser | A. fraseri |
| Fir, noble | A. procera |
| Hemlock, eastern | Tsuga canadensis |
| Horse-chestnut (Buckeye) | Aesculus spp. |
| Locust, black | Robinia pseudoacacia |
| Maple, Norway | Acer platanoides |
| Maple, red | A. rubrum |
| Maple, silver | A. saccharinum |
| Maple, sugar | A. saccharum |
| Maple, sycamore (plane-tree) | A. pseudoplatanus |
| Mimosa-tree (silktree) | Albizia julibrissin |
| Oak, bur | Quercus macrocarpa |
| Oak, northern red | Q. rubra |
| Oak, white | Q. alba |
| Pine, Austrian | Pinus nigra |
| Pine, Balkan | P. peuce |
| Pine, Coulter | P. coulteri |
| Pine, eastern white | P. strobus |
| Pine, Himalayan | P. griffithi |
| Pine, jack | P. banksiana |
| Pine, Japanese black | P. thunbergi |
| Pine, Japanese red | P. densiflora |
| Pine, Jeffrey | P. jeffreyi |
| Pine, Korean | P. koraiensis |
| Pine, limber | P. flexilis |
| Pine, loblolly | P. taeda |
| Pine, lodgepole | P. contorta |

| Common name | Scientific name |
|---|---|
| Pine, longleaf | P. palustris |
| Pine, Mexican white | P. ayacahuite |
| Pine, pitch | P. rigida |
| Pine, ponderosa | P. ponderosa |
| Pine, red (Norway) | P. resinosa |
| Pine, sand | P. clausa |
| Pine, Scotch (Scots) | P. sylvestris |
| Pine, shortleaf | P. echinata |
| Pine, slash | P. elliottii |
| Pine, Swiss stone | P. cembra |
| Pine, Virginia | P. virginiana |
| Pine, western white | P. monticola |
| Poplar, balm-of-Gilead | Populus tacamahaca cl. candicans |
| Poplar, balsam | P. balsamifera |
| Poplar, black | P. nigra |
| Poplar, birchleaf black | P. nigra betulifolia |
| Poplar, false Lombardy | P. cv. robusta |
| Poplar, Japanese | P. maximowiczi |
| Poplar, laurel | P. laurifolia |
| Poplar, Petrowsky | P. petrowskyana |
| Poplar, Razoumofsky | P. rasumowskyana |
| Poplar, Simon | P. simoni |
| Poplar, white (silver) | P. alba |
| Poplar, ? | P. cv. berolinensis rossica |
| Poplar, ? | P. caudina |
| Poplar, ? | P. cv. eugenei |
| Poplar, ? | P. cv. italica |
| Poplar, ? | P. nigra charkowiensis |
| Poplar, ? | P. cv. plantierensis |
| Poplar, ? | P. cv. Volga |
| Redcedar, eastern | Juniperus virginiana |
| Spruce, black | Picea mariana |
| Spruce, blue | P. pungens |
| Spruce, Norway | P. abies |
| Spruce, oriental | P. orientalis |
| Spruce, red | P. rubens |
| Spruce, Sakhalin | P. glehni |
| Spruce, Serbian | P. omorika |
| Spruce, Siberian | P. obovata |
| Spruce, white | P. glauca |
| Walnut, black | Juglans nigra |
| Willow, purple-osier | Salix purpurea |
| Willow, basket | S. viminalis |
| Yellow-poplar | Liriodendron tulipifera |

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